FORTY-SEVENTH ANNUAL REPORT

OF THE

New Jersey State Agricultural Experiment Station

AND THE

THIRTY-NINTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING JUNE 30

1926

THE LIBRARY OF THE
AUG 1 1927
UNIVERSITY OF ILLINOIS

PUBLISHED BY THE STATE
1927

THE UNIVERSITY
OF ILLINOIS
LIBRARY
630.7
N46r
v.47
cop.2

AGRICULTURE

FORTY-SEVENTH ANNUAL REPORT

OF THE

New Jersey State Agricultural Experiment Station

AND THE

THIRTY-NINTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING JUNE 30

1926

THE LIBRARY OF THE
AUG 1 1927
UNIVERSITY OF ILLINOIS

PUBLISHED BY THE STATE
1927

630.7
N46r
v.47
cop.2
Agric. lib.

Table of Contents

	PAGE
ORGANIZATION	xiii
State Station	xiii
Agricultural College Station	xiv
LETTERS OF TRANSMITTAL	xv
REPORT OF THE TREASURER	xvii
State Station	xvii
Agricultural College Station	xxix
REPORT OF THE DIRECTOR	1–60
Agricultural Biochemistry	3
Agricultural Economics	4
Agricultural Engineering	5
The Extension Service	6
Agronomy	8
Animal Husbandry	8
Dairy Husbandry	10
Chemistry	13
Entomology	14
Orchard Insect Investigations	15
Investigations of Dusts, Spreaders, Stickers and Diluents for spraying and Dusting Mixtures	17
Small Fruit Insect Investigations	19
Soil Infesting Insect Investigations	19
Cranberry and Blueberry Investigations	19
Bee Investigations	20
Mosquito Control	21
Practical Work of Mosquito Control	22
Horticulture	23
Pomology	23
Vegetable Gardening	25
Breeding and Floriculture	25
Oyster Research	27
Plant Pathology	28
Plant Activities	30
Other Activities	33
Plant Physiology	34
Poultry Husbandry	36
New Jersey Egg-Laying Contests	36
Research	36
Seed Control	38
Sewage Research	39
Soil Chemistry and Bacteriology	43
Publications	44

7 Aug 27 div. ex. v.47 1925/26 cont. EH.

633147

PAGE
    Research 44
    Extension 45
    Publications Issued 46
  List of Projects of the New Jersey Agricultural Experiment Station for 1926-27 53
  Staff Changes 59
    Appointments 59
    Resignations 60
    Leave of Absence 60

REPORT OF THE DEPARTMENT OF AGRICULTURAL BIOCHEMISTRY 61

REPORT OF THE DEPARTMENT OF AGRICULTURAL ECONOMICS 63–71
  Potato Farms in New Jersey 64
    Practical Value of Economic Information 64
    Increased Acreage of Truck Crops 65
    Expenses Nearly Double 65
    Kinds of Changes 65
    Nine Successive Years on One Farm 66
  Poultry Farms in New Jersey 67
    Farm Income, Labor Income and Capital 67
    Size of Flocks 68
    Production per Bird 68
    Prices 68
    Lights 68
    Size of Farm 68
    Heavy Production Pays 69
  Alfalfa Work 69
  Calf Raising 69
  Transportation Survey 69
  Peach Study 70
  Cost of Producing Canhouse Tomatoes 70
  Cost of Producing Eggs 70
  Monthly Economic Review of New Jersey Agriculture 70
  Study of Milk Distribution 71
  Plans for the Year 1926-27 71

REPORT OF THE DEPARTMENT OF AGRICULTURAL ENGINEERING 73
  Organization 73
  Research Work 73
  Use of Electricity in Agriculture 73
  Campus Development 73

REPORT OF THE DEPARTMENT OF AGRONOMY 75–84
  Variety Tests 75
    Spring Grains 75
    Winter Grains 75
    Forage Crops 75
  Corn Breeding 78
  Size of Potato Seed Piece and Rate of Planting 80
  Grass and Turf Work 82

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY 85–101
  Buildings and Equipment 85
  Livestock 85
    Swine 85

PAGE
Sheep 85
Health of Herd 85
Research Problems 86
A Study of Farrowing Records 86
A Study of the Effect of Protozyme on the Utilization of Food by Swine 87
Study of Protein Selection by Swine 99
A Comparison of the Effect of Fishmeal and Tankage on the Rate of Growth and on the Texture and Quality of the Carcass of Swine 99
Hogging Down Corn 100

REPORT OF THE DEPARTMENT OF BIOLOGY 103–114
Introduction 103
Weather and Water Conditions 103
Temperature and Spawning of Oysters 104
Further Studies of the Occurrence and Behaviour of Oyster Larvae 107
The Vertical Distribution of Oyster Larvea 108
Setting 109
The Death of the 1925 Oyster Set 110
Miscellaneous 112
The Bayhead-Manasquan Canal 112
Solid Fill Across Barnegat Bay 112
Summary 112
References 113

REPORT OF THE DEPARTMENT OF CHEMISTRY 115–133
Introductory 115
Administration 115
Inspection of Commercial Fertilizers During 1925 116
Registrations 116
Reports of Tonnage 116
Rules and Regulations 117
Wholesale Prices of the Essential Elements of Plant-Food for 1925 117
Station's Trade Values 118
Inspection 118
Cost of Plant-Food in Commercial Fertilizers 122
Ground Bone 123
Summary of the Results Obtained with Mixed Fertilizers Examined During the Inspection of 1925 124
Inpection of Agricultural Lime During 1925 126
Inspection 126
Inspection of Insectides and Fungicides During 1925 126
Inspection 126
Arsenic Residue on Apples 126
Inspection of Commercial Feeding Stuffs During 1925 128
The New Jersey Feed Law 128
Registrations 129
Tonnage of Feeding Stuffs Sold 129
Inspection 129
Results of the Examination 129
Summary of the Inspection 131

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY 135–149
Experimental 135
Breeding Experiment with Dairy Cattle 135

PAGE

- Comparison of Linebreeding with Outcrossing 135
- Rations for Dairy Heifers During Winter Months 135
- Minimum Milk Requirements for Raising Dairy Calves 136
- Normal Growth of Dairy Animals 138
- Effect of Temperature and Humidity on the Milk Production of Dairy Cows 138
- The Relation of the Ductless Glands to Milk Production 139
- Sutdies of the Color Pigmentation in the Skin of Dairy Cattle 139
- A Study of the Changes that Take Place in the Conformation of Dairy Cattle 139
- ABabcock-Gerber Method for Determining the Percentage of Fat in Ice Cream 139
- Effects of Ultraviolet Irradiation and Green Feed on the Mineral Constituents of the Blood and Milk of Cows on Aequate Diet, but Protected from Direct Sunlight 141
- A Comparion of the One-Day Sample vs. the Composite Sample in the Analysis of Milk for Butterfat 143

Creamery Inspection 144
Extension 145
Advanced Registry 147
The Dairy Herd 148

REPORT OF THE DEPARTMENT OF ENTOMOLOGY 151–254

- Introduction 151
- Correspondence 151
- Insects of the Year 171
- Investigations 171
  - Climate and Inspect Investigation 171
    - A Study of the Body Moisture, Fats and Nitrogen Occurring in the Apple Tent Caterpillar (*Malacasoma Americana*) Throughout Its Life Cycle 174
  - Orchard Insect Investigations 175
    - Codling Moth 175
    - A Report on the Investigation of the Oriental Peach Moth (*Laspeyresia motlesta* Busck) for 1925 184
    - Some Tests of Para-dichlorobenzene Dissolved in Soluble Pint Tar Creosote in the Control of Boring Insects in Living Plants 196
    - Investigations of Dusts, Spreaders, Stickers and Diluents for Spraying and Dusting Mixtures 199
    - Investigation of Stickers in Dusting Mixtures 206
    - Oil Sprays and Emulsifiers 206
    - A Study of the Fundamental Principles Influencing the Spreading, Adherence and Distribution of Arenical Sprays 208
    - The Distribution, Quantity and Adherence of Lead Arsenate Deposited in Field Spraying and Their Relation to Twig and Lead Growth 209
  - Small Fruit Insect Investigations 213
    - The Raspberry Crown Borer 213
- Report of the Cranberry Substation 215
  - Plant-Food Studies 215
  - Arsenical Weed-Killers 216
  - Sanding 217
  - False Blossom 217
  - Weather in 1925 218
  - Rot Control 218

PAGE
A Comparison of Copper-Lime Dust and Liquid Bordeaux Spray to Control Cranberry Rot 219
The Effect of the Water Table on the Growth and Yield of Cranberries 221
The Effect of Cranberry Bog Flowage Water on the Larvae of the Japanese Beetle, *Papillia japonica* Newm 222
Insects of the Cultivated Blueberry 224
The Nature of Cranberry Bog Peat 225
Soil Infesting Insect Investigations 228
Bee Investigations 229
Mosquito Control 237

REPORT OF THE EXTENSION SERVICE 255–261
Administration 255
Reorganization Cuts Overhead Cost 255
Closer Coordination of Extension Activities 255
Improvement in Plans of Extension Work 255
Cooperation in Conducting Extension Work 255
The Extension Staff 256
Farmers Believe in Extension Work 256
Agriculture 256
Home Makers Believe in Home Economics 257
Home Economics 257
Boys' and Girls' Club Work 258
General Activities 259
Agricultural Program 259
Agricultural Conferences 259
Exhibits 260
Finances 261
Cooperation of Farmers' Organizations 261

REPORT OF THE DIVISION OF HORTICULTURE 263–312
Fiftieth Anniversary Meeting of the New Jersey State Horticultural Society 263
Second Shipment of Peaches to New Zealand 263
Split-Pit Peaches 263
Rate of Growth of Individual Fruits of the Peach 265
Rate of Growth of One Elberta Fruit 266
Rate of Growth of J. H. Hale Fruits 267
Peach Breeding 269
Technical Phase 269
Seedling in the Nursery 270
The Station Collection of Peach Species, Varieties and Types 270
The Self-Fruitfulness of Peach Varieties 275
Apple Breeding 275
Carnation Breeding 276
Hydrangea Culture 276
The Culture of Perennials 277
Iriz Rhizome Rot 277
Culture of Dahlias 277
Report of the Department of Pomology 278
Spraying Experiment with Peaches 278
Apple Pollination Studies 280
Cultural Studies of Strawberries 283
Observations on the Fruit-Bearing Habit of Wealthy, McIntosh and Baldwin, Horticultural Farm, New Brunswick, New Jersey, 1925 284

PAGE
Rate of Growth of Apple Fruits 287
Comparative Yield of Several Standard Varieties of Apples, Horticultural Farm Orchard, New Brunswick 288
Propagation and Distribution of Peach Seedlings 290
Variety Orchards 291
Grape Investigations 294
Small Fruit Varieties 294
  Strawberry Varieties 294
  Raspberry and Blackberry Varieties 296
Report of Weather Observations 300
Report of the Vegetable Department 301
Plant-Food Studies with Carrots 302
Celery 303
Plant-Food Studies with Sweet Potatoes 303
Plant-Food Studies with Asparagus 308
Plant-Food Studies with Cantaloupes 308
Influence of Amounts and Time of Applying Nitrate of Soda to Peppers, Sweet Corn and Tomatoes 309
The Effect of the Size of Asparagus Roots Upon the Development and Yields of the Plants 310
Studies of the Growth Responses of Horticultural Plants, Associated Chemical Changes in Foods, and the Utilization of Nutrients 311

REPORT OF THE DEPARTMENT OF PLANT PATHOLOGY .... 313—355
New Jersey Plant Diseases, 1925 314
  Diseases Arranged by Hosts 315
Potato Spraying in 1925 324
  Test on the J. Harry Kandle Farm 325
  Test on the I. B. Van Derveer Farm 326
  Spraying Tests with Late-Crop Cobblers on the J. H. Kandle Farm 328
  Summary 329
Apple Blotch Studies 329
Appple-Scab Studies 332
Ascospore Discharge Studies 332
Pea Root-Rot Studies 334
  Soil Temperature and Infection 334
  Resistance of *Aphanomyces Euteiches* to Drying 335
  Hosts of the Pea Root-Rot Organism 335
  Effect of Root-Rot on Transpiration 336
  Longevity of Zoospores in the Soil 336
  Effect of Lime and Sulfur on Root-Rot Infection 337
  Possible Control Measures 338
  Summary 339
Further Studies on Arsenical Injury of the Peach 339
Effects of Arsenate of Lead 341
  Effect of Lime and Sulfur on Arsenical Injury to Leaves 342
  Leaf Injury vs. Twig Injury 343
  Effect of Time of Application and Weather Conditions on Amount of Injury 345
  Effect of Defoliation on Nodal Cankering 345
  Summary 346
  References 346
Sweet Potato Disease Studies in 1925 347
  The Commercial Value of Varieties of Sweet Potatoes Resistant to Stem Rot 348
  The Residual Effect of Lime and Sulfur on the "Pox" Disease of Sweet Potatoes 349
  The Effect of the Potash Salts on the Yield of Sweet Potatoes and the Stem-Rot Diseases 350

PAGE
The Effect of Sulfur and Lime on the Scurf Disease of Sweet Potatoes on the Plant and on Production 351
The Effect of Organic Mercury Compounds, Mercuric Chloride and Formaldehyde on the Control of the Scurf or Soil Stain Disease of Sweet Potatoes 352

REPORT OF THE DEPARTMENT OF PLANT PHYSIOLOGY 357–372
Effects of Boron on the Growth of *Vicia Faba* in Culture Solutions 357
Absorption of Nitrogen from Culture Solutions by Plants 360
The Effect of Different Water Levels on the Growth of Cranberries 365
Procedure and Description of the Plots 366
Discussion of Results 369
The Effect of Different Water Levels on the Vegetative Growth 369
Effect of Different Water Levels on the Yield 370
Effect of Different Water Levels on the Percentage of Rot 371
References 372

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY 373–406
Publications 373
General and Personal Service 373
New Jersey Egg Laying Contests 374
Vineland International Egg Laying Contest 374
Bergen County Contest 376
New Jersey Poultry Exhibitions 378
Research Program 379
The Experimental Poultry Plant 379
Nutrition Experiments 380
Poultry Pathology 389
New Brunswick 389
Vineland Laboratory 397

REPORT OF THE DEPARTMENT OF SEED ANALYSIS 401
Introduction 401
Administration 401
Seed Inspection 401
Official Samples 401
Unofficial Samples 402
Plant Identification 403
Legume Inoculation 406

REPORT OF THE SEWAGE SUBSTATION 409–520
Introduction 409
Chapter 45, Laws of 1926 410
Staff 411
Scope of Investigations 411
Publications 411
Effect of Lime on Sludge Digestion 412
Introduction 412
Laboratory Experiments 412
Methods 412
Results 414
Discussion 440
Summary 443
Imhoff Tanks 443
Introduction 443
Results 444

PAGE

Discussion 459

Summary 462

Separate Sludge Digestion Tank Experiments 463

Introduction 463

Results 463

Discussion 479

Amounts of Lime Necessary for Adjustment of Fresh Solids and Material in Digestion Tanks 481

Method 481

Results 481

Methods of Application of Lime 489

Summary 489

General Discussion on the Effect of Lime on Sludge Digestion. 489

Studies on Film Accumulation in the Sprinkling Filter Bed 498

Methods 498

Results 498

Discussion 501

Summary 505

Distribution and Succession of Protozoa in Imhoff Tanks 506

Introduction 506

Results 507

Summary and Conclusions 519

References 520

REPORT OF THE DEPARTMENT OF SOIL CHEMISTRY AND BACTERIOLOGY .. 521–540

The Availability of Nitrogen in Nitrate of Soda, Ammonium Sulfate and Dried Blood with Varying Ratios of Phosphoric Acid and Potash 521

Season of 1925 521

Plan of Experiment 521

First Crop of 1925—Rape 522

Residual Crop of 1925—Sorghum 524

The Combined Crops—1925 524

Percentage Nitrogen Recovered—Combined Crops 1922-1925, Inclusive 524

Summary 526

References 528

Continuous Wheat and Rye With and Without a Legume Green Manure Crop—Season 1925 528

The Continuous Growing of Corn With a Legume and Non-Legume Green Manure Crop—Season 1925 530

The Influence of Fertilizers on the Composition of the Soil 530

References 533

The Treatment of Alkali Soils with Alpho 533

References 538

Making Artificial Manure from Salt Marsh Hay by the "Adco" Process 538

Compost 1 539

Compost 2 539

Compost 3 539

Soil Microbiology 540

REPORT OF THE DEPARTMENT OF SOILS AND CROPS 541–568

Completion of Soil Survey 541

Completion of the Bergen Area Report 541

A Compilation of the Soil Survey Data 541

Soil Classification and Utilization in New Jersey 541

Summary 541

Land Utilization 542

A Fertilizer Experiment in Burlington County 542

PAGE
A Fertilizer Experiment in Monmouth County 543
Appendix 1 543
  Acreage of Soil Types of New Jersey in Order of Relative Extent 543
Appendix 2 546
  Acreage of Soil Types of New Jersey—Series Classification... 546
Appendix 3 550
  Acreage of Soil Types of New Jersey—Textural Classification 550
Appendix 4 556
  Soil Classification and Utilization in New Jersey 556
Appendix 5 566
  Burlington County Fertilizer Experiments—Sweet Corn 566
Appendix 6 567
  Monmouth County Fertilizer Experiments—Sweet Corn and Tomatoes 567

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS*

NEW BRUNSWICK, N. J.

STATE STATION ESTABLISHED 1880
BOARD OF MANAGERS

His Excellency A. HARRY MOORE..........Trenton, Governor of the State of New Jersey
JOHN M. THOMAS, D.D., Litt.D., LL.D.. .New Brunswick, President of Rutgers University
JACOB G. LIPMAN, Ph.D...................Director; and Dean of the College of Agriculture

County	*Name*	*Address*
Atlantic	Charles Fitting	Hammonton
Bergen	Arthur Lozier	Hackensack
Burlington	Aaron Collins	Moorestown
Camden	Fred S. Niepling	Waterford
Cape May	Ralph Schellinger	Green Creek
Cumberland	Frank G. Merithew	Vineland
Essex	N. A. Carle	Newark
Gloucester	Wilbur F. Beckett	Swedesboro
Hudson	Arthur J. Hoffman	Jersey City
Hunterdon	Egbert T. Bush	Stockton
Mercer	John W. Hendrickson	Ewingville
Middlesex	James Neilson	New Bruns'k
Monmouth	H. W. Herbert	Englishtown
Morris	Robert Loree	Florham Park
Ocean	James E. Otis	Tuckerton
Passaic	Isaac A. Serven	Clifton
Salem	Andrew Schnetzler	Elmer
Somerset	R. V. Lindabury, Jr.	Bernardsville
Sussex	Thomas C. Roe	Augusta
Union	William S. Tyler	Plainfield
Warren	E. C. Brill	Stewartsville

STAFF

Jacob G. Lipman, Ph.D.......................Director
Howard F. Huber, B.Sc.......................Assistant Director
Irving E. Quackenboss.......................Chief Clerk, Secretary and Treasurer
Russell E. Long.............................Senior Clerk
Harriet E. Gowen............................Chief Stenographer and Clerk

W. H. Allen, B.S.......Acting Poultry Husb.
H. G. Bailey....Foreman Vegetable Gardening
George I. Ball............Creamery Inspector
John W. Bartlett, B.Sc...Dairy Husbandman
James A. Beatty, Foreman, Egg-Laying Contests
F. R. Beaudette, D.V.M....Poultry Pathologist
Chas. S. Beckwith, M.Sc...Asst. Entomologist
F. S. Beckwith, B.Sc..Fert. and Feed Sampler
J. W. Bellis..................Farm Manager
Carl B. Bender, M.Sc..Asst. Dairy Husband'n
James J. Black, D.V.M.....Asst. Poultry Path.
A. W. Blair, A.M...............Soil Chemist
M. A. Blake, B.Sc..Chief, Div. of Horticulture
Sadie Boyce..............Asst. Seed Analyst
Herminie R. Broedel, Litt.B....Asst. Editor
†Forrest Button, B.Sc.Asst. Dairy Husband'n
J. Carncross, B.S.......Res. Asst., Agr. Econ.
Chas. S. Cathcart, M.Sc...........Chemist
J. H. Clark, M.Sc............Asst. Pomologist
F. H. Clickner, M.S...Poultry Research Spec.
F. M. Colt, B.S...........Asst. Seed Analyst
C. H. Connors, B.Sc..Assoc. in Plant Breeding
Roger W. DeBaun, B.S.........Assoc. Editor
Martin Decker, B.S...Asst. Poultry Specialist
B. F. Driggers, M.Sc. Asst. in Cranberry Investigations
W. H. Dumont, M.S..........Asst. Biologist
Edward E. Evaul, B.S..Res. Asst., Farm Crops
Leo J. Faneuf, B.Sc........Assistant Chemist
Arthur J. Farley, B.Sc..........Pomologist
Jessie G. Fiske, M.Sc...........Seed Analyst
E. J. Frizzell, B.S....Res. Asst., Dairy Husb.
Fred Gaunt..................Dairy Herdsman
J. M. Ginsburg, Ph.D., Biochem., Entomology Invest.
Frank Groendyke....Fert. and Feed Sampler
E. R. Gross, B.Sc....Chief, Agr. Engineering
C. M. Haenseler, Ph.D....Assoc. Plant Path.
Clyde C. Hamilton, M.S..Assoc. Entomologist
Willard S. Hamilton, Foreman, Egg-Laying Contests
Thomas J. Headlee, Ph.D......Entomologist
Frank G. Helyar, B.Sc..Animal Husbandman
H. Heukelekian, Ph.D., Biochemist, Sewage Investigation
R. Hutson, B.Sc..Asst. Entomologist in Apicul.
Carl Ilg...............Lab. Asst. Entomology
C. D. Jones, M.S., Biochemist, Cranberry and Blueberry Invest.
Henry Keller, Jr., M.Sc......Agr. Economist
Linwood L. Lee, B.S., Res. Specialist, Land Utilization
D. B. Lucas, M.S........Asst. Agr. Engineer
William H. Martin, Ph.D...Plant Pathologist
Harry C. McLean, Ph.D...Soil Bacteriologist
Frank W. Miller..........Asst. Entomologist
P. A. Morse, B.S...Res. Asst., Dairy Products
†G. W. Musgrave, M.S..........Agronomist
Thurlow C. Nelson, Ph.D..........Biologist
G. T. Nightingale, Ph.D..Biochem., Horticul.
George A. Osborn, A.M.............Librarian
Daggmar Peterson, M.A..Asst. Sewage Invest.
C. S. Platt, M.S.......Asst. Poultry Specialist
A. L. Prince, M.Sc........Asst. Soil Chemist
W. R. Robbers.....Supt. Advanced Registry
Willem Rudolfs, Ph.D., Biochemist in Ento., Chief of Sewage Invest.
Lyman G. Schermerhorn, B.Sc..Olericulturist
A. C. Schlott..Foreman, Egg-Laying Contests
W. C. Skelley, M.Sc...Asst. An. Husbandman
Elizabeth G. Skillman, B.Sc..Asst. Librarian
J. A Small, B.S..............Seed Inspector
L. R. Smith, B.Sc.........Assistant Chemist
H. B. Sprague, M.S.........Asst. Agronomist
Arthur L. Stahl, B.S.....Asst. in Seed Lab.
Louis A. Stearns, M.Sc....Asst. Entomologist
Clarence H. Steelman....Orchard Foreman
John Thompson.............Swine Herdsman
†W. C. Thompson, B.Sc..Poultry Husbandman
Archie C. Wark...........Assistant Chemist
Ralph L. Willis, B.Sc.....Assistant Chemist
Carl R. Woodward, A.M..............Editor
P. J. Zeller, B.S., S.B..Chem., Sewage Invest.

---

*Staff list revised to June 15, 1926.
†On leave of absence.

AGRICULTURAL COLLEGE STATION, ESTABLISHED 1888
BOARD OF CONTROL

The Board of Trustees of Rutgers College in New Jersey

EXECUTIVE COMMITTEE OF THE BOARD

W. EDWIN FLORANCE	New Brunswick
WILLIAM S. MYERS	New York City
JAMES NEILSON	New Brunswick
ALFRED F. SKINNER	Newark

STAFF

JACOB G. LIPMAN, Ph.D.	Director
HOWARD F. HUBER, B.Sc.	Assistant Director
HENRY P. SCHNEEWEISS, A.B.	Chief Clerk

A. W. Blair, A.M.	Soil Chemist
L. G. Campbell	Field Asst., Plant Path.
Eliz. Clark, M.S.	Res. Asst., Plant Path.
René J. Dubos	Res. Asst., Soil Microbiology
B. R. Fudge, M.S.	Res. Asst., Plant Physiol.
J. M. Ginsburg, Ph.D.	Biochem., Ent. Invest.
Clyde C. Hamilton, M.S.	Assoc. Entomologist
Thomas J. Headlee, Ph.D.	Entomologist
Jacob S. Joffe, Ph.D.	Res. Asst., Soils
J. G. Lipman, Ph.D.	Soil Chem. & Bacteriologist
W. H. Martin, Ph.D.	Plant Path.
H. C. McLean, Ph.D.	Soil Bacteriologist
Augusta E. Meske	Asst. Entomologist
C. D. Chupp, Ph.D.	Asst. Plant Path.
A. L. Prince, M.Sc.	Asst. Soil Chemist
W. R. Robbins, M.Sc.	Res. Asst., Plant Phys.
W. C. Russell, M.S.	Biochem., Nutrition
J. L. Seiler, Jr., B.S.	Res. Asst., Agr. Econ.
John W. Shive, Ph.D.	Plant Physiologist
Jas. A. Sutfin	Res. Asst., Plant Path.
Florence G. Tenny, B.S.	Res. Asst., Soil Microbiology
S. A. Waksman, Ph.D.	Microbiologist, Soil Res.
Allen G. Waller, M.S.	Res. Spec., Agr. Econ.
Clara H. Wark	Laboratory Asst., Soil Bact.
Herbert Winsor	Field Asst., Soils

EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS ORGANIZED 1912

Staff

HERBERT J. BAKER, B.S., Director

W. H. Allen, B.Sc.	Specialist, Poultry Husb.
A. S. Barnhart, B.S.	County Agent at Large
Mrs. Marion C. Bell, B.Sc.	Spec., Home Mgt.
Anna C. Bergen	Financial Clerk
Helen G. Bishop, B.Sc.	Asst. Spec., Clothing
L. M. Black, B.S.	Asst. Spec., Poultry Husb.
Herminie R. Broedel, Litt.B.	Asst. Editor
Marion Butters, B.Sc.	Asst. Director
H. R. Cox, M.S.A.	Spec., Soil Fert. and Agron.
Roger W. DeBaun, B.S.	Assoc. Editor
Marie C. Doermann, B.Sc.	Specialist, Foods
E. A. Gauntt, B.S.	Asst. Spec., Dairy Husb.
†Mrs. C. H. Griebel	Specialist, Clothing
E. R. Gross, B.Sc.	Specialist, Agr. Engin.
A. M. Hulbert	Asst. Director
M. Ethel Jones, M.A.	Specialist, Girls' Club Work
†W. F. Knowles, A.B.	Specialist, Agr. Econ.
A. F. Mason, M.Sc.	Specialist, Fruit Growing
Mildred B. Murphey, B.S.	Home Demonstration Agent at Large
C. H. Nissley, B.Sc.	Specialist, Veg. Growing
E. J. Perry, B.S.	Specialist, Dairy Husbandry
Bernard F. Ramsburg, B.Sc.	Club Agent at Large
E. L. Scovell, M.F.	Spec., Farm Forestry
Carl R. Woodward, A.M.	Editor

County Agents

County	
Atlantic	Arthur R. Eldred, B.Sc. Chas. Cianciarulo, B.S., Assoc.
Bergen	W. Raymond Stone
Burlington	C. A. Thompson, B.Sc. Leonard R. Smith, B.S., Assoc.
Camden	Samuel F. Foster, B.Sc.
Cape May	W. Collins Thomas, B.S.
Cumberland	
Essex	Irvin T. Francis, A.B.
Gloucester	George E. Lamb, B.Sc.
Mercer	Amzi C. McLean, B.Sc.
Middlesex	Orley G. Bowen, B.S.
Monmouth	Ellwood Douglass Marvin A. Clark, B.S., Asst.
Morris	A. Howard Saxe, B.Sc.
Ocean	Ernest H. Waite, B.Sc.
Passaic	Harold E. Wettyen, B.Sc.
Salem	R. O. Vaughn, M.A.
Somerset	Harry C. Haines
Sussex	Douglas A. Evans, B.S.
Warren	Howard Mason, B.Sc.

Home Demonstration Agents

County	
Atlantic	Mrs. Edith G. Norman, B.Sc.
Bergen	Mrs. Elizabeth M. Berdan Helen H. Powell, B.S.
Camden	Emily Kellogg, B.Sc.
Essex	Mrs. M. C. Shepard
Gloucester	Janet G. Banks
Mercer	J. Kathryn Francis, B.Sc.
Middlesex	May Truman, B.Sc.
Monmouth	Mabel E. Smith, B.Sc.
Morris	Helen C. Spaulding, B.S.
Passaic	Margaret H. Hartnett, B.S.
Somerset	Charlotte Embleton
Sussex	Alice B. Clifford, B.S.
City of Paterson	Mrs. Cecilia Brogan

County Club Agents

County	
Mercer	Joseph B. Turpin, B.Sc.
Middlesex	R. E. Harman, B.S.
Monmouth	D. M. Babbitt, B.Sc.
Morris	James R. Porter, B.S. Agr.
Ocean	Elsie R. Horne, B.Sc.
Salem	W. G. Frisbie, B.S.
Warren	L. W. Hill, B.Sc.

---

†On leave of absence.

Letters of Transmittal

To His Excellency, A. Harry Moore, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Forty-seventh Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10, 1880, and which is chapter 106 of the laws of that year.

JAMES NEILSON,
President.

NEW BRUNSWICK, N. J., July 31, 1926.

To His Excellency, A. Harry Moore, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2, 1887, and with an act of the Legislature of this State, approved March 5, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey, maintaining Rutgers Scientific School, the New Jersey State College, for the benefit of Agriculture and Mechanic Arts, the Thirty-ninth Annual Report of the operations of the Department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

JOHN M. THOMAS,
President.

NEW BRUNSWICK, N. J., July 31, 1926.

Treasurer's Report

Irving E. Quackenboss, in account with the New Jersey State Agricultural Experiment Station, July 1, 1925 to June 30, 1926.

Appropriation for Salaries, Wages and Maintenance

Appropriation	$93,621.00
Transferred to Appropriation for Replacement of Light Delivery Truck	550.00
Net	$93,071.00
Collections from Dairy Department	21,699.81
Collections from Animal Husbandry Department	4,536.63
Collection of Feed Inspection and Registration Fees	26,235.26
Collection of Fertilizer Inspection and Registration Fees	20,208.49
Total	$165,751.19

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	98,589.00
Bills submitted to State Comptroller for direct payment	
Books and Periodicals	307.71
Coal	1,653.10
Dairy Farmhouse Supplies	90.85
Electric Current and Gas	2,470.64
Express, Freight and Cartage	1,940.28
Feed and Shavings	19,170.57
Fertilizer	868.33
Hardware, Tools, etc.	1,097.16
Insurance	25.00
Laboratory and Field Equipment	2,112.45
Laboratory and Field Supplies	3,444.34
Laundry Work	214.42
Live Stock	1,063.45
Miscellaneous Hour and Day Labor	10,334.90
Office Furniture and Equipment	1,396.51
Photographic Work and Supplies	418.51
Postage	999.49
Registration of Animals	75.50
Repairs and Alterations to Buildings	1,816.86
Repairs to Equipment	1,387.28
Repairs to Roads and Development of Campus	4,128.68
Small Printing and Stationery	1,289.61
Telephone and Telegraph	2,172.12
Traveling Expenses	4,800.25
Trees, Seeds and Vines	645.41
Vehicular Transportation, Supplies, Repairs, etc.	2,178.86
Veterinary Services and Medicine	856.40
Sundries	166.85
	165,714.53
Amount reverting to State Treasury	36.66
Total	$165,751.19

Appropriation for Printing Bulletins and Circulars

Appropriation	$16,000.00
Collections from Department of Publications	50.74
Total	$16,050.74
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
For Printing Bulletins and Circulars	16,035.47
Amount reverting to State Treasury	15.27
Total	$16,050.74

Appropriation for Abolishing Mosquito Breeding Salt Marshes

Appropriation	$18,000.00
PAYMENTS	
By Treasurer of the Experiment Station	
Salaries and Wages	8,562.50
Bills submitted to State Comptroller for direct payment	
Advertising	27.84
Laboratory and Field Equipment	230.00
Laboratory and Field Supplies	8.80
Miscellaneous Hour and Day Labor	518.90
Ford Car (Exchange)	290.00
Office Furniture and Equipment	153.63
Overland Car (Exchange)	490.88
Photographic Work and Supplies	7.26
Postage	36.35
Repairs to Equipment	200.00
Small Printing and Stationery	21.58
Telephone and Telegraph	887.72
Traveling Expenses	988.40
Vehicular Transportation, Supplies, Repairs, etc.	677.57
	13,101.43
Amount reserved by requisition until next fiscal year (For Building Salt Marsh Ditch cutting unit)	4,881.69
Amount reverting to State Treasury	16.88
Total	$18,000.00

Appropriation for the Investigation of Oyster Propagation

Appropriation	$5,800.00
PAYMENTS	
By Treasurer of the Experiment Station	
Salaries and Wages	3,560.00
Bills submitted to State Comptroller for direct payment	
Coal	38.75
Electric Current and Gas	63.29
Express, Freight and Cartage	17.14
Insurance	44.00
Laboratory and Field Equipment	541.84
Laboratory and Field Supplies	319.73
Miscellaneous Hour and Day Labor	440.50
Office Furniture and Equipment	27.00
Photographic Work and Supplies	13.20
Postage	100.00
Repairs to Equipment	428.01

Telephone and Telegraph	55.65
Traveling Expenses	97.73
Wharfage for Boats	52.60
	5,799.44
Amount reverting to State Treasury	.56
Total	$5,800.00

Appropriation for the Department of Poultry Husbandry

Appropriation	$24,880.00
Collections for Sales of Poultry and Eggs and Fees for Testing for Bacillary White Diarrhea	6,699.42
Total	$31,579.42

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	16,595.00
Bills submitted to State Comptroller for direct payment	
Coal	341.00
Electric Current and Gas	639.85
Feed and Shavings	4,590.98
Hardware, Tools, etc.	109.45
Hatching Eggs	760.00
Laboratory and Field Equipment	1,032.75
Laboratory and Field Supplies	617.09
Miscellaneous Hour and Day Labor	1,436.12
Photographic Work and Supplies	45.60
Postage	675.00
Poultry Stock	1,290.00
Repairs and Alterations to Buildings	2,143.84
Repairs to Equipment	82.68
Traveling Expenses	1,191.74
	31,551.10
Amount reverting to State Treasury	28.32
Total	$31,579.42

Appropriation for Seed Inspection

Appropriation	$8,500.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	5,835.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	664.37
Laboratory and Field Supplies	198.29
Miscellaneous Hour and Day Labor	303.05
Photographic Work and Supplies	21.05
Repairs to Equipment	34.72
Seed Samples	34.45
Small Printing and Stationery	951.39
Traveling Expenses	218.78
Vehicular Transportation, Supplies, Repairs, etc.	212.86
Sundries	5.00
	8,478.96
Amount reverting to State Treasury	21.04
Total	$8,500.00

Appropriation for Experimental Work in Vegetable Production

Appropriation	$3,000.00
Collections for Sales of Vegetables	25.70
Collections for Sales of Flowers	4,211.36
Total	$7,237.06

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	3,802.50
Bills submitted to State Comptroller for direct payment	
Books and Periodicals	4.50
Coal	650.00
Fertilizer	62.13
Laboratory and Field Equipment	673.54
Laboratory and Field Supplies	142.10
Miscellaneous Hour and Day Labor	1,032.20
Repairs and Alterations to Buildings	766.93
Small Printing and Stationery	11.00
Traveling Expenses	37.26
Seeds and Plants	27.10
Sundries	6.00
	7,215.26
Amount reverting to State Treasury	21.80
Total	$7,237.06

Appropriation for Insecticide Inspection

Appropriation	$1,000.00

PAYMENTS

Bills submitted to State Comptroller for direct payment	
Laboratory Supplies	705.99
Stationery	.65
Telephone and Telegraph	1.15
Traveling Expenses	285.08
	992.87
Amount reverting to State Treasury	7.13
Total	$1,000.00

Appropriation for Farm Demonstration

Appropriation	$85,585.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	81,163.66
Bills submitted to State Comptroller for direct payment	
Miscellaneous Hour and Day Labor	90.00
Office Furniture and Equipment	104.98
Postage	166.47
Printing Bulletins and Circulars	3,420.97
Small Printing and Stationery	110.00
Telephone and Telegraph	2.63
Traveling Expenses	519.52
Vehicular Transportation, Supplies, Repairs, etc.	6.77
Total	$85,585.00

Appropriation for Cranberry and Blueberry Investigation

Appropriation	$10,000.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	6,300.00
Bills submitted to State Comptroller for direct payment	
Books and Periodicals	80.80
Express, Freight and Cartage	15.00
Laboratory and Field Equipment	1,248.95
Laboratory and Field Supplies	397.30
Miscellaneous Hour and Day Labor	236.80
Office Furniture and Equipment	163.03
Photographic Work and Supplies	37.10
Postage	123.00
Rental of Building for Research Laboratory	150.00
Small Printing and Stationery	19.20
Telephone and Telegraph	71.15
Traveling Expenses	1,148.20
Vehicular Transportation, Supplies, Repairs, etc.	1.77
	9,992.30
Amount reverting to State Treasury	7.70
Total	$10,000.00

Appropriation for Egg-Laying and Breeding Tests

Appropriation	$10,000.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	6,362.50
Bills submitted to State Comptroller for direct payment	
Feed and Shavings	3,387.30
Repairs and Alterations to Buildings	249.25
	9,999.05
Amount reverting to State Treasury	.95
Total	$10,000.00

Appropriation for Experimental Work in Growing White Potatoes, Sweet Potatoes and Tomatoes

Appropriation	$14,600.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	9,545.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	802.11
Laboratory and Field Supplies	304.77
Miscellaneous Hour and Day Labor	633.15
Photographic Work and Supplies	91.68
Telephone and Telegraph	464.50
Traveling Expenses	2,547.38
Seed	205.54
	14,594.13
Amount reverting to State Treasury	5.87
Total	$14,600.00

Appropriation for Legume Inoculation Inspection

Appropriation	$2,000.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	1,365.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	188.34
Laboratory and Field Supplies	34.78
Legume Samples	45.85
Postage	160.00
Repairs to Equipment	90.79
Traveling Expenses	95.03
Vehicular Transportation, Supplies, Repairs, etc.	15.05
	1,994.84
Amount reverting to State Treasury	5.16
Total	$2,000.00

Appropriation for Poultry Exhibitions and Premiums

Appropriation	$6,500.00

PAYMENTS

Bills submitted to State Comptroller for direct payment	
Exhibition Equipment and Supplies	1,219.58
Premiums Awarded and Allotments to Poultry Associations for Educational Meetings and Exhibits	4,182.54
	$5,402.12
Amount reverting to State Treasury	1,097.88
Total	$6,500.00

Appropriation for Sewage Investigation

Appropriation	$5,800.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	5,500.00
Bills submitted to State Comptroller for direct payment	
Postage	155.00
Telephone and Telegraph	60.82
Traveling Expenses	78.98
	5,794.80
Amount reverting to State Treasury	5.20
Total	$5,800.00

Appropriation for Milk and Cream Inspection

Appropriation	$3,000.00
Collections for Testing Glassware and Testers' Licenses Issued	491.02
Total	$3,491.02

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	2,040.00
Bills submitted to State Comptroller for direct payment	
Traveling Expenses	1,450.58
	3,490.58
Amount reverting to State Treasury	.44
Total	$3,491.02

Appropriation for the Investigation of Root Rot of Peas

Appropriation	$3,500.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	2,820.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	380.00
Postage	70.00
Telephone	.15
Traveling Expenses	211.88
Seed	11.10
	3,493.13
Amount reverting to State Treasury	6.87
Total	$3,500.00

Appropriation for the Investigation of Bee Husbandry

Appropriation	$3,000.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	2,390.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	26.00
Laboratory and Field Supplies	32.00
Rental of Land for Apiary Site	32.00
Small Printing and Stationery	48.00
Traveling Expenses	471.64
	2,999.64
Amount reverting to State Treasury	.36
Total	$3,000.00

Appropriation for Experimental Work in Vegetable Production in North Jersey

Appropriation	$2,500.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	920.00
Bills submitted to State Comptroller for direct payment	
Laboratory and Field Equipment	1,055.70
Laboratory and Field Supplies	253.09
Postage	125.00
Small Printing and Stationery	12.50
Traveling Expenses	105.86
Seed	20.40
	2,492.55
Amount reverting to State Treasury	7.45
Total	$2,500.00

Appropriation for Combating the Oriental Peach Moth

Appropriation	$7,000.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	4,710.00
Bills submitted to State Comptroller for direct payment	
Ford Car (Exchange)	290.00
Laboratory and Field Equipment	189.92
Laboratory and Field Supplies	425.58
Miscellaneous Hour and Day Labor	209.30
Photographic Work and Supplies	19.35
Small Printing and Stationery	295.53
Traveling Expenses	498.87
Vehicular Transportation, Supplies, Repairs, etc.	347.84
	6,986.39
Amount reverting to State Treasury	13.61
Total	$7,000.00

Appropriation for Experimental Work with Small Fruits

Appropriation	$2,500.00

PAYMENTS

By Treasurer of the Experiment Station	
Salaries and Wages	2,425.00
Bills submitted to State Comptroller for direct payment	
Miscellaneous Hour and Day Labor	46.20
Traveling Expenses	24.20
	2,495.40
Amount reverting to State Treasury	4.60
Total	$2,500.00

Appropriation for Exchange of Three Ford Cars

Appropriation	$1,350.00
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
Exchange of Three Ford Cars	1,349.61
Amount reverting to State Treasury	.39
Total	$1,350.00

Appropriation for Replacement of Light Delivery Truck

Appropriation	$1,000.00
Transferred from Salaries, Wages and Maintenance Appropriation	550.00
Total	$1,550.00
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
Replacement of Light Delivery Truck	1,511.30
Amount reverting to State Treasury	38.70
Total	$1,550.00

Appropriation for Books and Bindings

Appropriation	$1,500.00
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
Books and Bindings	1,499.25
Amount reverting to State Treasury	.75
Total	$1,500.00

Appropriation for Repairs to New Jersey Hall Roof

Appropriation	$600.00
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
Repairs to Roof	597.94
Amount reverting to State Treasury	2.06
Total	$600.00

Supplemental Appropriation for Repairs to Buildings and Fences at the Egg-Laying Contests in Bergen and Cumberland Counties

Supplemental Appropriation	$6,000.00
PAYMENTS	
Bills submitted to State Comptroller for direct payment	
Repairs	5,991.68
Amount reverting to State Treasury	8.32
Total	$6,000.00

SUMMARY

Total Appropriations	$337,236.00
Total Collections Credited to Appropriations	84,158.43
Total	$421,394.43

Summary of Analysis of all Expenditures

Advertising	$27.84
Books and Periodicals	1,892.26
Coal	2,682.85
Electric Current and Gas	3,173.78
Exhibit Equipment and Supplies	1,219.58
Express, Freight and Cartage	1,972.42
Feed and Shavings	27,148.85
Fertilizer	930.46
Ford Cars Exchanged (5)	1,929.61
Hardware, Tools, etc.	1,206.61
Insurance	69.00
Laboratory and Field Equipment	9,145.97
Laboratory and Field Supplies	7,020.56
Laundry Work	214.42
Live Stock	3,113.45
Miscellaneous Hour and Day Labor	15,281.12
Office Furniture and Equipment	1,845.15
Overland Car Exchanged	490.88
Photographic Work and Supplies	653.75
Postage	2,610.31
Premiums Awarded and Allotments to Poultry Associations	4,182.54
Printing Bulletins and Circulars	19,456.44
Registration of Animals	75.50
Rental of Building for Cranberry Research Laboratory	150.00
Rental of Land for Apiary Site	32.00
Repairs and Alterations to Buildings	11,566.50
Repairs to Equipment	2,276.08
Repairs to Roads and Development of Campus	4,128.68
Replacement of Light Delivery Truck (Reo)	1,511.30
Salaries and Wages	262,485.16
Small Printing and Stationery	2,759.46
Sundries	177.85
Telephone and Telegraph	3,715.89
Traveling Expenses	14,771.38
Trees, Seeds and Vines	944.00
Vehicular Transportation, Supplies, Repairs, etc.	3,440.72
Veterinary Services and Medicine	856.40
	415,158.77
Amount reserved by requisition until next fiscal year (For Building Salt Marsh Ditch cutting unit)	4,881.69
Amount reverting to State Treasury	1,353.97
Total	$421,394.43

Collections Account

RECEIPTS

From Dairy Department Collections for Sales of Milk, Cream and Dairy Stock	$21,699.81
From Animal Husbandry Department Collections for Sales of Swine	4,536.63
From Chemistry Department Collections of Fertilizer Inspection and Registration Fees	20,208.49
From Chemistry Department Collection of Feed Inspection and Registration Fees	26,235.26
From Department of Publications Collection for Sales of Bulletins and Circulars	50.74
From Poultry Department Collections for Sales of Poultry and Eggs and Fees for Testing for Bacillary White Diarrhea	6,699.42
From Floriculture Department Collections for Sales of Flowers	4,211.36
From Vegetable Gardening Department Collections for Sales of Vegetables	25.70
From Dairy Department Collections for Testing Glassware and Testers' Licenses Issued	491.02
From National Bank of New Jersey For Interest on Deposits	132.53
	$84,290.96

PAYMENTS

To State Treasurer Collections for Sales of Milk, Cream and Dairy Stock	$21,699.81
To State Treasurer Collections for Sales of Swine	4,536.63
To State Treasurer Collections of Fertilizer Inspection and Registration Fees	20,208.49
To State Treasurer Collections of Feed Inspection and Registration Fees	26,235.26
To State Treasurer Collections for Sales of Bulletins and Circulars	50.74
To State Treasurer Collections for Sales of Poultry and Eggs and Fees for Testing for Bacillary White Diarrhea	6,699.42
To State Treasurer Collections for Sales of Flowers	4,211.36
To State Treasurer Collections for Sales of Vegetables	25.70
To State Treasurer Collections for Testing Glassware and Testers' Licenses Issued	491.02
To State Treasurer For Interest on Deposits	132.53
	$84,290.96

The Auditing Committee of the Experiment Station has examined the accounts of the Treasurer of said Station, and has found them correct.

(Signed) EGBERT T. BUSH,
THOMAS C. ROE,
Auditing Committee.

Financial Statement

AGRICULTURAL COLLEGE STATION

EXPENDITURES BY ABSTRACTS CHARGEABLE AGAINST HATCH, ADAMS, AND PURNELL FUNDS FOR THE YEAR ENDED JUNE 30, 1926

Abstracts	*Hatch*	*Adams*	*Purnell*
Salaries	$10,716.01	$12,457.50	$12,887.50
Labor	829.00	332.16	655.50
Stationery and Office Supplies	180.84	33.57	109.55
Scientific Supplies	626.34	959.30	653.24
Feeding Stuffs	360.00	.....	30.47
Sundry Supplies	274.87	120.32	200.72
Fertilizers	15.39	.....	.....
Communication Service	136.60	.....	1.63
Travel Expenses	1,453.49	.....	1,324.40
Transportation of Things	26.36	3.28	27.96
Heat, Light, Water, and Power	70.75	736.76	92.16
Furniture and Fixtures	32.70	66.60	617.76
Library	9.60	.....	8.50
Scientific Equipment	81.40	163.75	1,537.85
Livestock	.....	.....	112.00
Tools, Machinery, and Appliances	121.54	7.58	1,212.90
Buildings and Land	58.22	81.02	493.89
Contingent Expenses	6.89	38.16	33.97
	$15,000.00	$15,000.00	$20,000.00

HENRY P. SCHNEEWEISS,
Treasurer.

Report of the Director

Jacob G. Lipman

In its beginning, the second quarter of the present century finds agricultural specialization more marked than ever. This tendency is readily accounted for by geographical factors, the character of the consumers, the competition of the industries for labor, and the items of taxation and production costs.

Specialization is most apparent in the fields of poultry and dairy husbandry and in horticulture. The number of commercial poultry plants is increasing rapidly. The trend in this field of farming is toward specialization in breeding and hatching. Poultry stock of excellent quality is being developed with judgment and intelligence far in advance of the conditions which prevailed a decade ago. Commercial hatcheries are increasing their output and are adding to the quality of their product from year to year. In dairying, as in the poultry industry, specialization is producing tangible results. Aside from the notable improvement in the quality of dairy stock, there is more differentiation as between one grade of milk and another. The chemical composition and the bacterial content of milk are more intelligently considered, both by the producers and consumers. In consequence, our city milk markets are establishing milk prices in keeping with the quality of the different grades of milk.

The same trend is evident in the production of tree fruits, small fruits, and vegetables. The consuming public is becoming more discriminating as to appearance and edible quality of horticultural products. The producers must adjust themselves to market needs by more careful growing, grading, and packing. The growth of the suburban element in the state's population is reflected in the expansion of ornamental plantings, both public and private. A number of communities in the state are developing comprehensive policies as to parks and playgrounds. Individual householders are showing a greater appreciation of the aesthetic side of suburban life. The increasing number of public parks and playgrounds is being accompanied by a keener study of grasses, shrubs, and shade trees.

The trends and tendencies just noted bear a direct relation to the activities of the Experiment Station. New research problems are constantly being presented to the departments of the station. Because of the specialization in agricultural production and the greater degree of discrimination being shown by the residents of the state both in the purchase of agricultural commodities and in the development and improvement of the countryside, not only are there new and numerous problems presented to the members of the research staff, but there is also a more insistent demand for various educational activities grouped under the head of agricultural extension. The demand for information and instruction comes with particular insistence from the younger farmers and gardeners and from members of garden clubs and others interested in ornamental horticulture.

It may also be noted that, whereas the earlier types of research carried on by the Experiment Station were intended primarily to solve the problem of the agricultural producers, some of the research projects taken up more recently by the station are of primary concern to the consumer and to the non-agricultural portion of our communities. Reference may be made in this connection to investigations in the fields of human nutrition and of sanitation. The well-known work of the Experiment Station in developing effective methods of mosquito and fly control, in studies on biological methods of sewage disposal, and in vitamin studies as related to soils and soil treatment on the one hand and the growth of animals on the other, are all examples of research which deal in a large way with the well-being of our population, both urban and suburban.

It is gratifying to note that the resources for carrying on the several activities of the Experiment Station have become more adequate. The land holdings of the College of Agriculture have been augmented by the purchase of Gebhardt Farm No. 1, adjoining the property of the institution and comprising somewhat less than 90 acres of land. This area is suitable for the production of alfalfa, corn, and other crops. Thanks to the intimate cooperation which exists between the College of Agriculture and the Experiment Station, the latter is in a position to utilize the recently acquired land for the development of the service of the animal husbandry, dairy husbandry, and agronomy departments. Some additions may be noted to the laboratory facilities of the station. A portion of the space in the attic of the Dairy and Animal Husbandry Building has been placed at the disposal of the department of agricultural biochemistry. A slight increase in laboratory space was made possible in the Agricultural Administration Building through alterations in that building. Better utilization of space may also be noted in the branch library and in the greenhouses.

Certain of the building and laboratory needs are quite pronounced. It is essential that adequate space and equipment be made available for the department of sewage research, and it is hoped that funds may be appropriated in the near future for the equipping of satisfactory laboratories for this department. Space for the purpose could be found in the Short Course Building at the College Farm. It is also important that the attic of the Dairy and Animal Husbandry Building be finished and nutrition laboratories installed. There is likewise need for better laboratory facilities in the departments of entomology, plant pathology, plant physiology and soil science. It is recommended that as soon as may be expedient, funds be appropriated for the construction of a Rural Engineering Building, the completion of the Horticultural Building and the erection of a separate building for the department of soil science.

Increasing numbers of students from other states and from foreign countries are asking that they be granted the privilege of working in the station laboratories in order that they may become familiar with the methods employed and the problems under investigation.

The members of the research staff, while showing a loyal interest in the work assigned to them, cannot always ignore more tempting offers from sister institutions and from commercial establishments where technical training and experience of a particular type are desired. Consideration should also be given in this connection to the tendency of living costs to increase rather than to decrease. Since it is obviously to the advantage of the institution to employ only such persons as have both ability and a sound training, every effort should be made to maintain high salary standards.

The Experiment Station as an institution should concern itself in a larger way with the conservation and development policies of the state. It should be in a position to contribute to a well-defined plan dealing with the conservation and development of the physical resources of New Jersey. Its contributions might deal particularly with land utilization, reclamation, and improvement. Some of the land now used for agricultural purposes must sooner or later be set aside for use as building sites, driveways, and streets. Another portion of agricultural land must be dedicated for use as public parks, game preserves, and playgrounds. It is evident that much foresight is needed for guiding wisely our efforts of land utilization. A study should be made of population trends and, insofar as possible, the needs of our towns and cities anticipated. Transportation, water supplies, sewage disposal, land values, taxation, and other important factors are involved and should be dealt with in a broad-gauge way. In other words, the service which the Experiment Station is rendering should be so planned as to fit best into a comprehensive scheme of state development. The other departments and institutions of the state will no doubt cooperate in the future, as they have in the past, in the common effort to promote the well-being of the residents of New Jersey.

The present annual report of the station, like its predecessors, contains a record of various activities. Some of these are briefly dealt with in the summaries of the department reports.

AGRICULTURAL BIOCHEMISTRY

The department of agricultural biochemistry was organized within the past year in order to provide for systematic research in the field of human nutrition. An animal laboratory, a chemical laboratory, experimental animals, and the necessary apparatus and equipment have been provided. Research of a fundamental nature was begun to determine the influence of the conditions of growth, particularly soil composition and treatment, on the nutritive value of various food crops, with special reference to the vitamin and ash content.

An attempt will be made to correlate the data concerning the vitamin content of food plants with the soil composition, with the thought of adding something to our knowledge of vitamins. At the present time, the vitamin B content of two varieties of wheat is being studied. The nutrition studies in the departments of animal husbandry, dairy husbandry, and poultry husbandry are being rounded out through the cooperation of this department.

AGRICULTURAL ECONOMICS

The organization of research for the development of a sound and active agricultural program has constituted one of the major projects of the department of agricultural economics. Commodity and subject matter committees in which the heads of the departments of the institution serve as chairmen have been organized. Their members include representatives from the staffs of the Experiment Station, Extension Division of the Agricultural College, and of the State Department of Agriculture. The statistician to all committees is H. B. Weiss of the state department and the secretary to all committees is Allen G. Waller. These committees have outlined the information necessary for the preparation of a sound agricultural program and are all assisting in assembling this information, of which much has been already procured.

The Department has taken over 400 farm management records in areas that had been surveyed in earlier years (1914-1917). The types of farming and the records taken are as follows:

	Farms
Poultry records	120
Gloucester County truck records	50
Cumberland and Salem Counties dairy records	40
Burlington County dairy records	48
Mercer County general records	29
Sussex County dairy records	31
Monmouth County potato records	48
Monmouth County dairy, truck and general records	35
Miscellaneous	3
Total	404

The changes in farm business on the same farms are being analyzed.

The average farm income of 48 potato farms in Central New Jersey for 1914 was $2793; on the same farms in 1924, it was $1521. In 1924, only 12 of these farms were growing any truck crops for sale, whereas in 1924, 25 of them were selling truck crops, with 1 farm having as high as 63 per cent of its acreage in truck crops. The details are given in the complete report of the department. They were reported in part, in the April, 1926, issue of the New Jersey Agriculture.

A survey of the farm business on 120 poultry farms showed an average net farm income of $2057 and a labor income of $1333.

Nine years ago a similar survey on 150 poultry farms showed an average net farm income of $1092 and an average investment of $7243 with a labor income of $730. Compared with the poultry year of 1915-1916 the average amount of capital necessary on poultry farms has doubled and the farm income and labor income have not quite doubled but nearly so. Apparently the poultry farms of New Jersey have fully held their own with other types of farming. They are carrying about one-third more birds, and in the current year, 18 per cent more than in the preceding year.

A study has been made of the possibilities of artificially curing alfalfa and forage. At the present time a plant for this operation is being constructed at the Walker-Gordon Farm. Arrangements are being made to investigate this undertaking from the economic and the nutrition standpoints. Consideration has also been given to the practicability of raising calves in New Jersey for replacements in our dairy herds, as an alternative to purchasing large numbers of animals from other states.

A survey of the farmer owned milk distributing plants of Massachusetts was made by Henry Keller, Jr., of this department. He was accompanied by county agents Douglass, Thompson, and Evans; dairy specialist E. J. Perry; and Paul B. Bennetch, of the State Department of Agriculture. *The Monthly Economic Review of New Jersey Agriculture* was issued on the fifteenth of each month. It has been the subject of many favorable comments.

The investigations of the coming year will deal largely with the agricultural program project. This will include some research on marketing, the field work for securing farm management records, and the assembling of the material already gathered.

AGRICULTURAL ENGINEERING

The following investigational work is under way in this department:

Vegetable Irrigation Survey.—By the survey method, data were collected on the production of vegetable crops under sprinkling irrigation. The factors of type and variety of crops, acreage grown, power used, pressure maintained, types of pumps, types of motors, and sources of water, as well as other factors were included in the scope of the survey.

Committee on Fertilizer Application.—A joint committee composed of representatives of the American Society of Agronomy, the National Fertilizer Association, the National Association of Farm Equipment Manufacturers, and the American Society of Agricultural Engineers has been asked to make a study of fertilizer distributing machinery. The head of the agricultural engineering department of the Station is serving as chairman of the American Society of Agricultural Engineers' subcommittee. It is proposed that the entire committee inquire into ways and means of improving on the types of machinery now in use and on the methods employed in applying fertilizers.

Use of Electricity in Agriculture.—The Agricultural Engineer has made an inquiry into the feasibility of conducting research work on the uses of electricity in agriculture. An effort is being made, with the aid of Dr. E. A. White, director of the committee on the Relation of Electricity to Agriculture, to initiate suitable investigations with the cooperation of power companies and manufacturers of electrical equipment. A survey of the present uses of electricity in New Jersey agriculture is now being carried on with the cooperation of H. B. Weiss, of the State Department of Agriculture. The American Society of Agricultural Engineers has appointed a committee, with D. B. Lucas, of this department as chairman, for promoting the study of the duty of cultivating machinery.

Campus Development.—The department has contributed in an engineering way, toward the following undertakings on the campus: Grades for the lawn at the Baldwin street entrance; levels, lines, and locations for walks, curbs, gutters, and drains for parts of the main drive; grades, plan, and location of walk at the Extension Building; grades for the parking area at the Administration Building; location of drive at the rear of the Poultry Building; levels for service roads at the campus and farm; complete set of plans for a calf barn for the dairy department; levels in the vicinity of the Dairy Barn; drainage survey of pasture for the dairy and animal husbandry departments; drainage survey on the farm; and design and advice on construction of septic tanks for the farm.

THE EXTENSION SERVICE

Reorganization Cuts Overhead Cost.—The reduction in the administrative staff of the Extension Service to a director and two assistant directors has effected a saving of $15,000 a year in the cost of administration and supervision. One assistant director supervises all agricultural work with both adults and juniors, and the other supervises all home economics work with both adults and juniors. Girls' club work is now carried on by county home demonstration agents, thus requiring less supervision from the State Extension Office and releasing men county club agents for full time with boys' clubs.

Closer Coordination of Extension Activities.—Closer coordination of extension work in its several branches has resulted in correspondingly more efficient service to the agricultural interests of the state.

Plans of Extension Work Improved.—Progress has been made during the past year in planning the work of the extension staff on a more definite and constructive basis. Attention has thus been directed to the most fundamental problems, enabling the staff to do more work and reach more people, and resulting in more specific and greater accomplishment in building the foundation on which the future prosperity of agriculture must rest.

Cooperative Relations.—Cooperation with county boards of agriculture and with the United States Department of Agriculture has continued harmonious. The director and assistant directors have attended as many of the meetings of the county boards of agriculture as possible. The success of extension work is in a large measure due to the cooperation of the county extension committees with the members of the extension staff in planning the county extension activities.

Farmers and Homemakers Believe in Extension Work.—A survey to find out what farmers think of extension work was conducted in 1925. There were visited 621 farms. Sixty-nine per cent of the farmers believe in extension work, and 64 per cent have changed their farm practices as a result of extension work. Only 3 per cent were opposed to the Extension Service. According to the survey, 64 per cent of the homemakers are favorable to home economics extension work, and 41 per cent of the village homes and 15 per cent of the farm homes have adopted improved practices in homemaking as a result of extension teaching.

Home Economics Extension Work.—There are 1298 local women who cooperate with the county home demonstration agents and home economics. The Legislature of 1925 made an appropriateaching in their respective communities. The local leaders devoted on an average of ten days' time to extension work during the year. This has been a most valuable contribution to their communities and has enabled the extension workers to reach thousands of homes which otherwise would not have been served.

Agricultural Program.—The Extension Service, the Experiment Station, the State Department of Agriculture, the State Department of Conservation and Development, the State Federation of County Boards of Agriculture, and the State Grange are cooperating in a study to outline an agricultural policy for the State of New Jersey. The study has been going on for about a year, and preliminary reports are being prepared.

Agricultural Conferences.—A convention of bankers interested especially in agriculture was held at the Agricultural College in December. In the spring of 1925, the chairman of the Agricultural Committee of the State Bankers' Association and the director of the Extension Service visited 16 counties for conferences with bankers and the county agents for the purpose of developing closer cooperation between the bankers and the county extension agents.

The third annual conference of New Jersey Feed Dealers held in 1925 had an attendance of 168.

The annual encampment of boys and girls in club work held in June, 1925, had an attendance of 244 for the three-day period. This encampment is a reward for those who have done successful club work.

Exhibits.—The Extension Service cooperated with the Trenton Fair by making exhibits of boys' and girls' club work in agriculture and home economics extension specialists in spreading extension tion of $10,000 for two buildings at the Trenton Fair grounds for the boys' and girls' club exhibits. It is not too much to say that this exhibit of the boys' and girls' club work is one of the best exhibits at the fair.

The dairy club animals at the National Dairy Show took first prize with the Holstein herd; first with the Guernsey herd; first with the Jersey herd; first in showmanship. Eight states were in competition, including the best dairy states in the country.

AGRONOMY

Aside from the projects under way during the preceding year and continued through the present fiscal year, one other project has been started on which progress may be reported. This is an ecological survey of typical New Jersey pastures and is designed to indicate the more important factors which influence the carrying capacity of these pasture lands. Records from 135 farms—approximately one-half of the total number—have been obtained during the present year. All of these records are from farms on the coastal plains of the state, whereas the succeeding records will be largely from glacial soils of the northern part of the state.

Progress is also reported on the establishment of vegetative and fertilizer studies on certain grasses, particularly the several strains of bent grass largely used in the better greens of golf courses. This work, in cooperation with the Greens Committee of the United States Golf Association, is well under way and is proceeding in accordance with plans previously outlined.

During the present year, additional data have been obtained in the alfalfa seed source tests, in the red clover source tests, in the timothy strain tests, in the corn breeding project, in the spring grains variety tests, in the winter grains variety tests, and in the size of seed piece and rate of planting tests with potatoes. Several of these projects are now sufficiently advanced to justify the publication of summaries of the data secured.

Although the agronomist has been on leave of absence since February 1, the work has been organized in such a manner as to permit the uninterrupted study of the problems outlined for the year.

ANIMAL HUSBANDRY

Livestock and Equipment.—During the year progress has been made in attaining a better equipment in livestock for the department. A frame building that had been moved from the campus in 1923 was completed as a sheep fold, and a flock of sheep was secured. In the spring of 1925, 10 sheep—5 purebred Shropshire ewes, purebred Shropshire ram, and 4 grades—were purchased.

During the summer 2 Hampshire ewe lambs and 2 Dorset ewe lambs were bought. Waldo Barron, of Slippery Rock, Pennsylvania, donated a fine Rambouillet ewe. In the early fall, 6 fine purebred Shropshires—5 ewes and 1 ram—were given to the department by Miss Ruth McTwombly, of Florham Park, New Jersey. With these additions and the natural increase, the department now has a flock of 22 sheep, excellent material for teaching as well as for research work in an industry that is now commanding more attention on the part of thoughtful livestock men in New Jersey.

Progress has been made in the improvement of the herd of swine. The Duroc Jerseys, which a few years ago were decidedly off-type, have been improved by careful breeding, so that it is not exaggeration to say that the department has one of the best, if not the best, college herd of Durocs in the East. Last fall the sale of breeding animals to farmers in New Jersey, which was discontinued in 1919 because of the inferiority of our stock, was resumed and three fine Duroc boars were sold at nominal prices.

Three excellent Berkshire sows were purchased at a nominal price from Richard Wais, one of our Short course graduates, and one of the leading Berkshire breeders in the East. Through the kindness of Roy Patrick, of Quinton, New Jersey, who has lent breeding animals to the department, a fine herd of Hampshire swine is being established. There are in the herd at the present time 175 head of swine, including 140 young pigs and the following boars and brood sows:

	Boars	*Brood Sows*
Duroc-Jerseys	2	23
Poland-Chinas	–	3
Yorkshires	–	2
Berkshires	–	2
Hampshires	–	3
	2	33

The stock judging pavilion, which was moved from the campus to the farm, has had extensive repairs, including a new roof, electric light service, tan bark ring, and renovation of the heating system. The building is used by both the dairy and animal husbandry groups and is now in fine shape.

In equipping the new class room and laboratory building for the dairy and animal husbandry departments, the latter department finished off and equipped a large room on the third floor for chemical work in connection with animal nutrition. It was planned to use this for both instructional and research problems. With the addition of a biochemist to the staff of the Experiment Station, under the provisions of the Purnell funds, this laboratory and its equipment, as well as the room adjacent to it were turned over to the biochemist, with the understanding that the necessities of the department for biochemical work would be met by the new department of agricultural biochemistry.

Research.—The research program has been confined entirely to investigations in the feeding and management of swine. In the summer of 1924 a project on the study of protein selection by swine was started. Twelve pigs, about ten weeks of age, each of which was confined in a 1/20-acre lot, were fed, by means of separate self-feeders, seven different sources of protein—three of animal and four of vegetable origin. The feeds were carefully weighed in and out of the feeders each day to ascertain the daily consumption of each material, and the pigs weighed each week until they had attained a weight of 200 pounds, when they were removed from the experiment. It was planned to carry this project through several years before making any final conclusions. The second year of the project was completed during the months of July, August, and September, 1925.

Another project carried out by W. C. Skelley, was the study of the effect of Protozyme, a commercial product carrying enzymes that act on both carbohydrates and proteins, on the growth of swine. The work was divided into two parts, with suckling pigs and with shotes. Contrary to the results of the experiments with poultry, the investigations with swine did not disclose that either the young pig or the shotes made any substantial gains as a result of the Protozyme additions to the feed.

The determination of the value of hogging down corn as a practice for New Jersey farmers was the object of the third project. A plot of corn of about three acres was divided in two parts. One part was cut and husked and the corn fed by hand to 16 pigs in a pen. The other part was hogged down by 16 pigs who remained in the lot for 28 days. The pigs that were fed by hand each gained 0.45 pounds more per day, which at 14 cents per pound for pork meat 6.3 cents on the same feed than did those in the field. On the other hand, the cost of cutting, shocking, husking, carting, and feeding more than absorbed this apparent margin of profit.

Still another project is being conducted in cooperation with the United States Department of Agriculture and the National Live Stock and Meat Board. It has for its purpose the determination of the effect of tankage and fish meal on the growth of swine and on the quality of the carcass. During the year an attempt was made by means of preliminary tests, to ascertain whether there were any differences in the chemical composition of swine fed tankage and of those fed fish meal. No differences appeared in the nitrogenous composition of muscle fibre. The fat determinations have not yet been made. The project will be carried out in a more comprehensive manner during the summer of 1926.

DAIRY HUSBANDRY

Breeding Experiment with Dairy Cattle.—This project is now in its sixth year. In view of the fact that linebreeding is being compared with outcrossing, the project must be continued for several years more. At this time it may be reported that the daughters of the first outcross are making some very good records. No setbacks have taken place in the breeding work of this experiment during the year and it is hoped that by another year some comparisons may be made between the first outcross and the original foundation animals used in the experiment.

Rations for Dairy Heifers During Winter Months.—This project was continued during 1925-26 when three groups of yearling heifers were wintered as follows:

One group was stabled in the dry stock barn and each animal was fed six pounds of grain a day with hay and silage ad libitum. The second group was fed hay and silage ad libitum in the dry stock barn. Group three were allowed to run outside all winter with only an open shed for shelter. Each animal in this group was fed ten pounds of grain a day with hay and silage ad libitum.

From the results noted it would seem that the economy in management was in favor of the method of feeding used with group two.

Minimum Milk Requirement for Raising Dairy Calves.—Progress has been made with this project during the year and several calves have been continued on a ration consisting of corn, oats, bran, oil meal, and skim-milk powder fed dry from the time the calf is 30 days of age. No ration has as yet been found that will keep young calves from having a period of setback after they are taken from the milk diet. It is proposed to add codliver oil to the above ration and continue several more calves for future trials. It is now planned to establish cooperative studies at the Walker-Gordon Farms. The administration of these farms has offered to furnish all the calves necessary for nutrition trials. Reports have come to hand from several farmers who have been feeding the skim-milk powder ration to young calves with excellent results. These calves, however, have not received the skim-milk powder ration until 60 days of age. It is felt that the department has saved New Jersey dairymen much money in its findings on calf feeding.

A Babcock-Gerber Method for Determining the Percentage of Fat in Ice Cream.—The department has made an important conbution to the ice cream industry with the completion of a Babcock-Gerber method for determining the percentage of fat in ice cream. Previous to this time, if accurate analytical results were desired in the analysis of ice cream, the Mojonnier method was to be recommended. On account of its cost the Mojonnier tester has been unsatisfactory for the small ice cream manufacturer. With the Mojonnier method used as a standard for comparison, the results of this experiment indicate that the Babcock-Gerber method as carried out by this department in its recent experiment is 231 per cent more accurate than any method other than the Mojonnier. The average variation from the Mojonnier on 40 samples of ice cream tested was 0.19 per cent with the Babcock-Gerber method.

This method seems well adapted for factory use where simplicity, cost of equipment, and time are important considerations. However, where absolute analytical results are desired the Mojonnier should be used. The usual cost of the Mojonnier tester is $1400, whereas the Babcock-Gerber method can be conducted with a testing outfit costing less than $100.

Effects of Ultraviolet Irradiation and Green Feed on the Mineral Constituents of the Blood and Milk of Cows on Adequate Diet, but Protected from Direct Sunlight.—It has been shown conclusively that the ultraviolet components of sunlight influence the mineral metabolism of animals. Some experimental workers report that irradiation with ultraviolet light increases the calcium and inorganic phosphorous in the blood of animals on diets deficient in minerals or in the antirachitic vitamin. In order to determine the effects of irradiation and green feed on the mineral constituents of the blood and milk of cows, five milking Holstein cows of various ages and stages of lactation were exposed daily to ultraviolet light from a mercury vapor lamp. These animals were protected at all times from direct sunlight. Conclusions from this trial would indicate that exposure to ultraviolet light for one-half hour per day will not noticeably affect the amount of milk produced, the percentages of calcium and phosphorus in milk, or the percentage of calcium or phosphorus in the blood of cows. There was some evidence that irradiation for one hour per day would increase the amount of calcium in the milk. Green alfalfa did not alter the mineral content of the blood or the milk. This experiment will be continued during the winter months of 1926-27, to determine the biological food value of milk from cows treated with ultraviolet rays.

A Comparison of the One-Day vs. the Composite Sample in the Analysis of Milk for Butterfat.—This project was undertaken to determine whether tests secured by farmers in their cow testing associations could be compared with the butterfat tests received at the creamery where composite samples were taken for a period of 15 days. Much dissatisfaction has been existing of late among farmers who are members of cow testing associations and who sell milk at the creamery on the butterfat basis. The farmers have used the one-day test of the cowtester as an argument that they were not receiving a fair test at the creamery. Results seem to indicate that the fat content of milk is so variable from day to day that any one-day's test cannot be taken as an index of the test of the composite sample which represents all the milk delivered during the 15-day period.

During the year much interest has been shown in problems of research by the ice cream manufacturers in the Metropolitan district. The head of the department of dairy husbandry has been in close touch with the Metropolitan Ice Cream Association, and beginnning July 1, Lewellyn Dibble, a graduate of Cornell Agricultural College, will be employed on full time as a graduate assistant. His efforts will be entirely in the field of ice cream research.

CHEMISTRY

The activities of the department of Chemistry during the fiscal year ending June 30, 1926, were confined largely to the inspection work required by the laws regulating the sale of commercial fertilizers, agricultural lime, insecticides, and commercial feeding stuffs. An emergency condition which developed in South Jersey necessitated the organization of a temporary branch laboratory in that section. This emergency work required the services of two chemists and, since the men connected with the department are needed for the regular work, some rearrangements in the service became necessary.

During the year all of the required inspections were made. They involved the analyses of 2704 samples. The results of these analyses were duly reported to the parties interested as soon as the results had been secured; and at the completion of each inspection, the results were printed in bulletins for general distribution.

Commercial Fertilizers.—Registrations of 1381 brands of mixed fertilizers and fertilizer materials were made by 136 manufacturers and brokers.

The inspections are made as efficient and thorough as was possible by sampling at many different places. The inspectors visited every county in the state and secured samples from 401 dealers and consumers. A sample of every brand was examined and duly reported on and, in many instances, duplicate samples were examined in accordance with request made by the purchasers. The total number of fertilizer samples examined was 1129.

There were 627 samples of mixed fertilizer examined. These samples represented 435 different brands—426 brands containing nitrogen, phosphoric acid and potash, 6 brands containing nitrogen and phosphoric acid, and 3 brands containing phosphoric acid and potash. Of these brands 116, or 27 per cent, were deficient; 47 in nitrogen, 60 in phosphoric acid, and 20 in potash. Everything considered, the fertilizers delivered within the past year were in a better condition than those of the preceding years.

Agricultural Lime.—Forty-four manufacturers registerd 89 brands during the year. A comparatively large number of samples were received, but many of them were unofficial samples. All of the samples received were examined and duly reported on.

Insecticides.—Fifty-seven manufacturers registered 311 brands during the year. The total number of samples examined was 138. The official samples were accompanied by 206 guarantees, 16 of which, or 7.8 per cent, were not sustained.

Commercial Feeding Stuffs.—During the year, 473 manufacturers and brokers registered 2221 brands. The inspections were thorough, for the inspectors visited every county in the state and collected a sample from the stock of 299 dealers and consumers.

The total number of samples examined was 1426, of which 1196 were official samples and the others were forwarded by individuals. The results of the guaranteed samples show that 503 fully satisfied the guarantees given, and in addition, 310 samples substantially satisfied the guarantees. There were 335, or 29.2 per cent of the samples deficient. The number of deficiencies found were as follows: protein 110, fat 96, and fiber 181.

ENTOMOLOGY

Twelve projects cover the work of this department; of these certain phases of eight have been actively pursued, whereas four have been temporarily inactive. Only those projects which have been active will be touched upon in the following paragraphs.

Climate and Insect Investigations.—In the field of climate and insect investigations it has been found, in the course of a study of the entire life cycle of the apple tree tent caterpillar, that different stages in the insect's development have widely different body water content. Beginning shortly after deposition, the water content of the egg was 48.5 per cent. This percentage of water decreased until hatching of the caterpillars, when the caterpillar's body was found to contain 39.4 per cent. From this point the water content rose rapidly, reaching 68.5 per cent six days after hatching and 85.1 per cent at the close of the second instar. From this time, the percentage of water in the body of the caterpillars remained about the same until pupation, when it dropped in the pupae to 71 per cent. The body water was still further decreased when the adults appeared and then amounted to 60 per cent. This seems to demonstrate that part of the entomologist's theory, stated some years ago, which maintained that body water requirements would be found to be different for the different stages in insect development. An interesting study of storage tissue, measured in terms of fat content of this insect throughout its life cycle was made. Shortly after deposition of the eggs a fat content of 9 per cent was found. This storage tissue decreased until hatching, when it amounted to 0.66 per cent. From this point, it rose until at the end of the second instar it was about 5.85 per cent. The fat content then rose about 8.04 per cent. From this time to pupation, the fat content rose with extreme rapidity, reaching, just before pupation, 18.71 per cent. In the pupae, principally by reason of a great decrease in water, the percentage of fat was 28.82 per cent. This fat was not all used up in the process of forming the new adult, because in the fresh adult the fat content was 26.1 per cent, thus leaving a supply of this storage tissue to be drawn upon for egg maturation and embryonic food supply. An interesting study of the relation of nitrogen, as representing the proteins, was made. The egg shells and the frothy covering of the egg mass were found to be about one-half nitrogen. The recently fully formed larvae within the egg ranged from 9 to

10 per cent nitrogen. Nitrogen rose slowly and relatively gradually to the time of hatching when it was about 15.13 per cent. From that point it diminished slowly until, in the pupae, it was about 8,26 per cent, and in the fresh adult it was about 9.03 per cent. Two points here are worthy of especial consideration. With the exception of the time when the storage tissue and the water had been enormously reduced—at the close of the egg stage and again in the fresh adult—the percentage of nitrogen in relation to total body weight remained approximately the same, indicating that about so much protein substance, and largely in the living protoplasm, was necessary to carry on the work of the organism. The actual amount of this living tissue increased as the organism increased. The second point is concerned with the comparatively increased amount of nitrogen in the adult and may well be concerned with the formation of the egg shells and the frothy covering.

Orchard Insect Investigations

Codling Moth.—A study has been made of the relative value of the codling moth cage, the thermal constant and the bait pan method. It was proposed in this study to determine the proper time for the application of spray mixtures for the control of the side worms of the codling moth. In orchards where not more than 50 per cent of the unsprayed fruit will become infested in the course of the season, the use of the thermal constant and the codling moth cage will afford excellent data for the proper timing of these sprays. As a matter of fact, the data seem to indicate that the thermal constant, which, of course, is obtained by figuring accumulated temperatures and requires merely accurate maximum and minimum thermometers, alone may serve as a pretty good agent for determining the right time to apply sprays under the above conditions. However, in orchards where more than 50 per cent, and especially where 100 per cent, of the unsprayed fruit will become infested by codling moth in the course of the season, the bait pan method seems to offer valuable service. The reason for this conclusion lies in the facts: (1) that when the moths appear in the orchard they enter the bait pans, thus informing the grower that they are abroad and prepared to lay eggs, and they continue to do so as long as they are present, and the weather is sufficiently favorable to afford proper conditions for egg deposition; (2) that the film coating of the fruit must be maintained throughout the period of time that the codling moth worms are trying to enter the fruit. At the request of the growers of some 1,500 acres of bearing fruit in the Glassboro district the entomologist is supervising the spraying for the summer season of 1926.

The Oriental Peach Moth.—The oriental peach moth has been found to have a considerable range of movement, clearly indicating that the problem of controlling this insect is not purely a question of individual orchards. A certain parasite, known as Macrocentrus, probably *ancylivora,* which is likewise thought to be a parasite of the strawberry leaf roller, was found very prevalent during the season of 1925 and, undoubtedly, was responsible for the enormous reduction which occurred in the injury done by the peach moth. This parasite has been found working vigorously in the season of 1926. The studies of oriental peach moth baits have not indicated any hope that the bait and trapping method will serve for purposes of control. It will, however, show when the moth is present. It will thus influence the spray, and as an adjunct of peach moth control, in the same way that the burlap band is utilized in connection with codling moth control. A study of the relative value of disking, plowing, and combined plowing and disking for the destruction of overwintering oriental peach moth larvae on the ground under the peach tree has shown that in soils where the disk can penetrate to the depth of 4 to 5 inches disking is about as efficient as plowing or as the combination. The application of nicotine sulfate in the regular spray practice, as indicated in the amount of fruit saved, more than pays the cost of the material and, since this material is mainly combined with the regular sprays, should prove a practical procedure. A study of the wintering quarters of the oriental peach moth conducted during the spring of 1926 indicates, where mummies occur in numbers under the trees, that 75 or 80 per cent of the oriental peach moth larvae overwinter on the ground. Around 15 per cent go over as larvae in cocoons on the parts of the tree from the crotch up, and the balance on the trunk within a distance of 8 inches of the surface of the ground. All these results indicate: (1) that peach trees should be treated with para-dichlorobenzene as for peach borer and mounded high; (2) that some time in April the soil beneath the peach tree should be cultivated with plow or disk or both; (3) that where the infestation is heavy the addition of nicotine sulfate to the regular spraying mixtures at the times recommended should be made. It has also been found that the overwintering larvae from the crotch of the tree upward are very shallowly placed and that, in all probability, a penetrating spray can be found which will destroy them; possibly a penetrating gas would do the work. These last points, however, remain for further investigation under the head of control.

European Red Mite.—Studies of the relative value of oil emulsions and miscible oils, which show a cost relation of one to three, for killing the overwintering eggs of the European red mite indicate clearly that a 2 per cent oil in the emulsion form is an efficient destroyer of the eggs of the European red mite as is 4 per cent oil in the miscible form. These studies also indicate that the percentage destroyed by either a 2 per cent oil emulsion or a 4 per cent miscible oil is probably too small to render satisfactory control, under favorable mite reproduction conditions, and that the strength of oil should be increased. The excellent control of the season of

1926 is, in the opinion of the entomologist, due to a combination of the oil treatment with unfavorable mite reproduction conditions.

Para-dichlorobenzene Dissolved in Soluble Pine Tar Creosote.—A test of this material against the larvae of the borer (*Euzophera semifuneralis*), working in the bark of linden trees and against the larvae of the mottled poplar and willow borer infesting pussywillows, has shown it to have extremely high penetrating and insecticidal power. The data, resulting from these tests are such as to indicate that this material should be tried against the codling moth and the peach borer in their winter quarters in the bark of the apple and peach trees.

Investigations of Dusts, Spreaders, Stickers and Diluents for Spraying and Dusting Mixtures

Water-Soluble Arsenic in Spray Mixtures.—It has already been demonstrated by at least three departments in the Experiment Station that lead arsenate, under certain conditions, results in serious burning of peach and apple tree foliage. It seems also to have been pretty well demonstrated that this burning is due to the presence of water-soluble arsenic, which is formed after the lead arsenate has been applied to the trees. Careful study of the relation of humidity, temperature, and sunlight to the formation of water-soluble arsenic indicates that beyond the presence of sufficient moisture in the mixtures to allow chemical transformation to take place, these factors have no particular influence on the formation of water-soluble arsenic. It is theorized but not proved that their apparent effect is exerted not through the formation of larger amounts of water-soluble arsenic, but through rendering the trees, foliage, and fruit more permeable to the water-soluble arsenic which is present under all conditions where the humidity in the mixture is sufficient to allow chemical change to take place. A careful study of the influence of hydrated lime, Kayso, and sulfur upon the formation of water-soluble arsenic from lead arsenate shows: (1) that, as long as there is an excess of hydrated lime, lime operates as a protective agent by taking up and rendering insoluble such arsenic as is freed from lead arsenate; (2) that as soon as the lime hydrate has been transformed to lime carbonate, decomposition of the lead arsenate is greatly accelerated and the water-soluble arsenic thus formed is not recombined in an insoluble form; (3) that a 75 per cent lime content of "Kayso" is occasionally, through long storage, transformed to lime carbonate in which case the addition of "Kayso" to lead arsenate results in the formation of greatly increased amounts of water-soluble arsenic and consequent increase in burning; (4) that the combination of elemental sulfur with lead arsenate has very little effect upon the appearance of water-soluble arsenic. A rather extensive study of compounds which, when added to lead arsenate, will result in rendering insoluble such water-soluble arsenic as appears, shows that charcoal and the oxides of zinc, iron, and aluminum are noticeably effective for this purpose and cheap enough to be within the range of practicability. Unfortunately, zinc oxide has been shown to burn both peach and apple when applied alone. The tests of the other materials thus far seem to indicate that they do not burn the plants when used alone.

Dusts-Stickers.—Starting with a simple material—petroleum oil, from which the unsaturated hydrocarbons have been removed—a very considerable series of possible adhesives for dust mixtures have been studied in the laboratory. As a result of this study, white oil and copper resinate are now undergoing field tests as stickers for insecticidal and fungicidal dusts.

Oil Studies.—Work in the northwestern part of the United States has demonstrated that a petroleum oil, which is free from the unsaturated hydrocarbons, is less toxic to plants than a petroleum oil in which the unsaturated hydrocarbons are still present. Quite independently the same conclusion was reached in investigations here at this laboratory. A study of the action of miscible oils in comparison with oil emulsions shows distinctly that the ordinary miscible oil does not eject its oil after being sprayed on the tree and that the oil emulsion promptly throws out its oil after being applied to the tree. This, we believe, is the explanation for the greater toxicity of ordinary oil emulsions. In an earlier section of this report it was pointed out, in the case of the European red mite overwintering eggs, that a 2 per cent oil emulsion spray was as toxic to the red mite eggs as a 4 per cent miscible oil. This conclusion is further borne out by laboratory data obtained from studying the effect of the same percentage of oil upon the eggs of the European red mite, whether that percentage was derived from miscible oils or oil emulsions. There is one miscible oil on the market which ejects its oil promptly after application. This miscible oil in equivalent amounts was found to be as toxic as the oil emulsions.

Relation of Arsenic to Growth of Apple.—In the course of studying spreaders and stickers for lead arsenate it has been found that the rate of growth of the apple tree is so rapid in the forepart of the season that, after the very early sprays, the amount of arsenic per square inch of leaf surface grows less, until the latter part of June, in spite of the fact that throughout this time heavy and frequent sprays containing lead arsenate are applied. After June, however, the increase of lead arsenate per square inch of leaf surface is very marked. This has a very distinct bearing upon spray practice for control of insects, especially codling moth. This fact seems to indicate that the spraying in the forepart of the season against the first brood of codling moth side-worms should be very intensive and that spraying against the codling moth in the latter part of the season can, where this practice is adopted, be very materially reduced.

Small Fruit Insect Investigations

Raspberry Crown Borer.—The raspberry crown borer is an insect of large importance in the growing of raspberries and blackberries in southern New Jersey and is particularly important in Atlantic County in the vicinity of Hammonton. During the past year the insect has been found to be single brooded; to pass the winter as small larvae, each in its blister-like cavity in the surface of the raspberry canes at a point varying from the surface of the ground to three inches below; and to be susceptible of destruction by the application of tobacco dust under proper conditions. The control methods of this insect by the use of tobacco dust require a further extensive experimental trial during the fall of 1926 before they are ready for general extension.

Soil Infesting Insect Investigations

Wire-Worms.—Work against the wire-worm has been largely confined to Passaic County in the Richfield district where it has been extensively troublesome to the market garden growers for a period of several years. Studies of the wire-worm have been extended to a point in Bergen County and to another point in Camden County. The results of these studies indicate that this kind of wire-worm infests lands under constant cultivation and crop production; that no material has been found which can be used against it in the presence of plants growing on the soil, without destroying the plants; that either carbon bisulfied emulsion or calcium cyanide can be used to destroy this insect and clean the land; and that of the two, calcium cyanide is much the cheaper. Field methods of applying calcium cyanide are in process of being perfected. Naphthalene has shown some promise as an insecticide for wire-worms but, at this date, has not yet got beyond laboratory tests.

Cranberry and Blueberry Investigations

Plant-Food Studies.—Tests of the year just closed on plant-foods for cranberry growing upon Savannah bottom bogs indicate that the practice of using the standard mixture worked out by the station in years past is giving excellent results. The decision has been reached, however, to recommend not over 500 pounds of this mixture for annual treatments.

Weed Killers.—"Weed Killer," the principal active agent of which is arsenic, has grown in the favor of cranberry producers enormously in the last few years and, thus far, there is no evidence of accumulative effect of arsenic. The principal problem seems now to be a question of varietal resistance, as between the cranberry plants and the weeds. Wild sweet potato has been killed in this way and the cranberry vines have been left practically unharmed. A special effort is now being made to find the percentage which will kill ferns and not injure the cranberry plants.

False Blossom.—False blossom, a disease of the cranberry plant, has been shown in the course of a survey to have been brought into the state on cuttings for cranberry plantings.

Dusts and Sprays.—Dusting has been shown to be not nearly so efficient in the control of cranberry rot as is bordeaux soap.

Water Table Studies.—Water table studies have shown that when the water is maintained at the surface of the bog, cranberry rot is greatly increased and, aside from that factor, the productive capacity of the vines greatly reduced. The best yields occur where the water table is from 9 to 12 inches below the surface.

Japanese Beetle.—A study of the ability of Japanese beetle grub to withstand spring flowage of the bogs indicates that the larvae can withstand ten days' flowage, but studies to determine the ability of Japanese beetle larvae to withstand winter flowage, which is normally held about four months, show that all perish.

Blueberry Insects.—Blueberry insects, consisting of the blueberry tip worm, a new species damaging the tips; a stem borer, resembling the raspberry stem borer; a lepidopterous larvae, boring into the berries; and the cranberry root worm, have been under investigation at the laboratory, but the data upon them have not reached the point where conclusions can be drawn.

Rejuvenation of Bogs.—The problem of the improvement of cranberry bogs that have ceased to be economically productive involves first the finding of the cause of their decadence and then the discovery of the corrective. The first phase of the problem has been under investigation during the year just closed. Plant-food is not always the limiting factor. As the years have passed, cranberry foliage and cranberry vines have dropped to the floor of the bog and have decomposed to a certain extent. The acidity of the peat in those bogs is extremely large, indicating a pH of 3.02 in the worst areas. Microflora and microfauna are extremely low. The problem is being attacked first from the standpoint of modifying the reaction by the addition of lime and possibly of other materials, but the results obtained thus far are not adequate to justify the drawing of any conclusions.

Bee Investigations

Fruit Pollination Studies.—Studies of fruit pollination, through the agency of honeybees, this year have confirmed those of previous years, showing that in southern New Jersey the need of honeybees as pollinators is very general, whereas in northern New Jersey wild bees render honeybees probably unnecessary. The details of the use of honeybees for this purpose have been further amplified to a point where unequivocal recommendations can be made.

Fumigants Against the Wax Moth.—A combination of ethyl acetate and carbon tetrachloride has been tried against the wax moth and found to be very satisfactory at 60°F. This material is no more effective than carbon bisulfied, but is non-inflammable and, consequently, more desirable from that standpoint.

Gaseous Chlorine as a Disinfectant for American Foulbrood.—Although this study has not yet been completed, enough data have been secured to indicate that gaseous chlorine is an efficient disinfectant for combs infected with American foulbrood.

Disease Resistant and High Production Strains of Honeybees.—Strains of honeybees resistant to European foulbrood have been developed in the New Lisbon bee yard and the time is approaching when the distribution of this stock can begin. High production strains are being studied at Lebanon and selections for high productiveness have been going on there during the past year. This bee breeding work is rendered practical by the fact that variations in the desired direction have been secured and methods of pure mating have been worked out. A sharp watch is now being kept for the appearance of American foulbrood-resisting sources of bees. When they are found the development of a strain resistant to that disease will be begun.

Mosquito Control

Biological Investigations.—Disappearance of Oil Larvicide in Polluted Waters.—For a number of years it has been known that oil used as a mosquito larvicide on sewage polluted waters very quickly disappeared; in some instances so quickly as to be totally ineffective as a larvicide. It has been shown that cultures of hydrocarbon-digesting bacteria destroy the oil film in 30 hours, under summer room temperature; that a mixed culture of hydrocarbon digesters and hydrogen sulfied producers destroy the film in 30 hours; and that hydrogen sulfide gas destroys the film in 3 hours. These results seem to explain the disappearance of the oil, because all sewage polluted waters contain these bacteria.

Mosquito Repellents.—In the study of mosquito repellents it has been found that thuja oil, cinnamic aldehyde, anisic aldehyde, bergamot oil, clove oil, and pyrethrum extract are the most effective substances tested. Pyrethrum extract and the other substances mixed with vaseline, cold cream, or face powders afforded considerably more protection than when applied alone. These substances, when used alone, afforded protection from one-half to one and one-half hours, and when used in jelly or powdered form lasted from two to three hours.

Food Supply of Mosquito Larvae.—An extensive study of the food supply of mosquito larvae has shown that chemical composition of the water determines the food supply, providing enough sunlight is present.

Salt Marsh Vegetation.—The exclusion of sea water from salt marsh meadows results in an enormous removal of the salts held in the soil, making large changes in the physical nature of the soil and in the vegetation upon it. The vegetation upon an open salt marsh is controlled by the height of water table and the salt content of the soil solution and, consequently, is susceptible of control by drainage operations. From a practical standpoint, these results indicate that enclosed marshes should be allowed to flood during the non-mosquito breeding season in order that the salt content of the soil may not be reduced to a point where typical salt marsh vegetation is destroyed.

Migration.—In August, 1925, a large brood of mosquitoes escaped from that section of the Upper Passaic Valley known as the Chatham Bridge and Canoe Brook Swamp. Fortunately, at no other point close enough to interfere with the study of movement from this area was there any marked issue of mosquitoes. The species concerned was approximately 90 per cent *A. sylvestris,* the fresh water swamp mosquito. This afforded a favorable opportunity to study mosquito movement from point of emergence outward. Two methods were used in making this study. The evening's collections were made on radii, extending from this point outward in all of the principal directions. The collections on these radii were made at approximately one and one-half mile intervals. This brood was exceedingly dense at the point of issue. Some idea of its density may be obtained from the statement that one man, collecting as rapidly as he could, secured 125 specimens in fifteen minutes and this number was limited only by his manual dexterity. These collections show a diminishing number of mosquitoes outward from the point of origin. In this instance the main armies moved north and south or up and down the Passaic Valley. The extreme range of movement was found to be seven miles, as the crow flies, from the point of origin. This brood, contrary to one recorded in 1917, did not cross the mountains bordering the valley. The second method employed in measuring movement consisted in the collection of approximately 20,000 mosquitoes at the point of origin, staining them with methylene blue, allowing them to dry, and releasing them. Full data upon the number of stained mosquitoes collected are not yet complete and the conclusions cannot, therefore, be given in this report.

Ditch Cleaning Machinery.—By the close of the fiscal year, seven motor ditch cleaning machines were at work upon the New Jersey salt marshes. Although certain weaknesses have been shown to occur in the practical use of these machines, the fact remains that they clean ditches at a cost of from one-fourth to one-sixth that of hand labor and do a far better job.

Ditch Cutting Machinery.—The ditch cutting machine on June 30 was approaching completion in the shops at Elizabethport and it is hoped that a test on its performance may be obtained during the coming fiscal year.

Practical Work of Mosquito Control

Correlation of County Effort.—Constant contact with the County Mosquito Commissions and their workers was maintained throughout the year and, insofar as possible, the work of one commission was adjusted to the work of other commissions. The annual meeting of the New Jersey Mosquito Extermination Association and the monthly meetings of the Associated Executives were prepared for, attended, and aided in every possible way that was within our power. Contacts were maintained with the New Jersey Federation of Women's Clubs and fifteen lectures were delivered upon the problem of mosquito control.

County Mosquito Accomplishment.—During the year just closed the County Mosquito Commission have: (1) cut 1,126,806 feet of ditching upon the salt marsh; (2) recut 976,020 feet of old ditching on the salt marsh; (3) built 14,576 linear feet of dike upon the salt marsh; (4) installed 42½ square feet of cross section tide gate outlet; (5) cut 134,505 feet of ditching upon the upland; (6) cleaned 1,319,826 linear feet of ditching on the upland; (7) maintained periodic inspection throughout the summer season of 1925 of 320,000 acres of upland territory and 130,725 acres of salt marsh; (8) eliminated, insofar as was at all possible, by all means at their command, all breeding found in this area.

Mosquitoes of the Year.—From the beginning of the spring of 1925 to the first of July, 1925, mosquitoes were markedly absent in the protected zones, although they were present in abundance in the unprotected sections. In July rainfall increased and mosquito breeding became more difficult to control. In certain sections of the metropolitan area mosquitoes were troublesome during the latter half of July and most of the month of August, but in the southern and central sections of the state the salt-marsh mosquito was held under excellent control. In the latter part of August mosquitoes in the section troubled disappeared and the rest of the year was free in the protected sections. From the beginning of spring to June 30, 1926, the metropolitan area has been very free from mosquitoes on the wing. In the central part of the state the salt-marsh mosquitoes have been held under excellent control. In fact, throughout the salt-marsh area the mosquito control has been very satisfactory. In the southern part of the state there have been large issues from undrained marshes, some of which have reached into protected zones. The species concerned in the outbreak of late July and August in the season of 1925 were *A. cantator, C. Pipiens,* and *A. Sylvestris* in the northern half of the state, and *A. sollicitans* in the southern half of the state.

HORTICULTURE

Pomology

The Pomology Department has conducted experimental projects during the year involving the spraying of peaches, propagation and distribution of promising peach seedlings, fertilization of apples, pollination studies of apples, cultural studies of grapes and strawberries and variety tests, including tree fruits, small fruits and grapes.

Spraying Experiments with Peaches.—The spraying experiments with peaches were again carried on at the Del-Bay Farms, Bridgeton, and at the Horticultural Farm, New Brunswick. Finely ground peat, zinc oxide and gypsum were found to be unsatisfactory as substitutes for hydrated lime in connection with the preparation of New Jersey Dry-Mix to be used in combination with lead arsenate. The peat and gypsum failed to prevent arsenical injury, while the zinc oxide itself proved to be very injurious to peach foliage. Further evidence was secured showing that it is desirable to increase the lime content of Standard New Jersey Dry-Mix (8-4-50 formula) when used in combination with lead arsenate. It is apparent that the lime content should be at least doubled and probably brought up to a point equal to 8 pounds of unslaked stone lime, the amount used in preparing self-boiled lime-sulfur. This problem requires further study in order to develop a spray mixture for peaches that will be just as effective as New Jersey Dry-Mix and safer to use on peach foliage in combination with lead arsenate.

Apple Pollination Studies.—In view of the increasing need for some definite information, based on New Jersey conditions, some apple pollination studies were started during the spring of 1926. The work during the first year was limited to a study of some of the varieties that might be used as pollinizers for Stayman. Jonathan, Delicious and McIntosh pollen gave the heaviest set of fruit on Stayman, with Golden Delicious, Melba, Wealthy, Rome, Starking, Starr and Grimes close seconds. Baldwin, Gravenstein and Smokehouse were found to be very poor pollinizers for Stayman.

Cultural Studies of Strawberries.—A new phase of work under this project was started during the past year in response to requests from growers for information relative to the reason for so many poor stands of runner plants in connection with the development of the common matted row. An experimental plot was established in Burlington County to study the effect of source of plants, time of planting, soil temperatures and various other factors that may be involved in the rooting and development of runner plants. Observations made up to July first, indicate that the type of plant as well as the time of planting have an important bearing upon the satisfactory development of the so-called matted strawberry row.

Propagation and Distribution of Peach Seedlings.—Over 7,000 trees of 15 varieties were distributed among 172 residents of New Jersey during the fall of 1925 and the spring of 1926. In addition to the distribution within the state, 429 trees of 13 varieties were distributed among 25 growers and Agricultural Experiment Stations in 16 other states and 2 foreign countries; namely, Canada and Australia. Another lot of budded trees is now growing in the Horticultural Farm nursery for distribution this fall, and next spring. Three varieties; namely, Cumberland, Radiance and Eclipse were released to New Jersey nurserymen during the year, a total of 30,000 buds being sent out for propagation purposes. Eight test orchards have now been established in different sections of the state, several of which produced fruit during the past year.

Vegetable Gardening

The work of the vegetable department in 1926 consisted of extensive fertilizer experiments on asparagus, cantaloupe, cauliflower, sweet corn, tomatoes and peppers at New Brunswick.

The sweet potato experiments begun in 1921 were continued in Ocean County on the farm of Chas. Underhill, at Lakewood, and consisted of plant-food studies to determine the influence of potash on the yield and form of the tuber, to compare sources of potash, and to determine the best combination of fertilizer ingredients for the sweet potato.

In spite of a dry and unfavorable season for the sweet potato the influence of potash on the relation of length to diameter was similar to the results secured in previous years and reported in Bulletin 398—Sweet Potato Studies in New Jersey.

The field experiments with sweet potatoes will be discontinued for the year of 1926, as the work has gone as far as possible under field conditions, and Dr. W. Rei Robbins will carry on controlled experiments at New Brunswick in the greenhouse to measure the effect of each of the several factors that may influence the shape of the sweet potato.

The Gloucester County asparagus project on the farm of Herbert Borden, was continued in its third year. The first commercial cuttings, 17 in number, were made from the bed between April 24 and May 30, 1925. Twenty-seven cuttings were made in 1926 between April 24 and June 29. The results in 1925 indicate that the conditions under which these experiments are being conducted are quite uniform as only slight differences in yields were found between the plots.

The striking difference in both yield and time of maturity between cantaloupes started in veneer bands and those planted in the field was recorded for the fourth year in 1925. The first picking from the veneer-band plants was made on August 15, and on August 31 for the field-planted seed. The average yield of firsts from the veneer-band plants was 226.8⅝ bushel baskets, as compared with 83.2 baskets of firsts from the field-planted seed.

Breeding and Floriculture

Peach Breeding.—Ten self-pollinated seedlings of Eclipse (a seedling of Belle self-pollinated) demonstrated a good segregation, being all yellow-fleshed, good quality, of about the same season as the parent and of the same habit of growth. One of these, ripening about one week earlier than Eclipse, was given an introduction number.

Of a number of seedlings fruiting for the first time in 1925, one maturing about with Carman, a large, attractive, yellow-fleshed freestone of good quality, will be named Golden Jubilee in honor of the fiftieth anniversary of the New Jersey State Horticultural Society held at about its ripening period. The naming is contingent upon further proof of merit.

In the spring of 1925, 9580 hand-pollinations were made on the 7 peach and nectarine trees which were covered. These crosses involve the securing of new varieties, especially early and late, the latter being in demand at the present time. Inter-specific crosses were made by using the almond, and a study of the inheritance of the smooth skin character of nectarine was begun.

From the breeding work of 1924, 1790 peach seedlings, mainly crosses of station seedlings on J. H. Hale, are growing in the nursery. These also include crosses with *Amygdalus kansuensis,* an extremely hardy bush peach from China.

The value of the Starr apple as a pollinator was proved, and 30 seedlings of Williams crossed with Starr and 124 seedlings of Wealthy crossed with Starr are now in the nursery.

J. H. Hale again proved itself self-unfruitful, only 7 fruits setting out of about 500 blossoms on a tree covered in 1926. Chinese Cling was again proved self-unfruitful.

Carnation Breeding.—One pink seedling was selected for final test before dissemination.

Crosses made during the year were to improve the scarlet, pink and yellow varieties. The commercial variety Laddie and a red sport of this variety were used. Laddie is sterile as a male and nearly sterile as a female because of ovular pistillody. A few seeds are formed occasionally.

The collection of Dianthus species was increased to 40.

Hydrangea Culture.—This popular and valuable project is being continued to determine the underlying causes of the color change.

Blue flowers are more difficult to produce at will, and aluminum sulfate, the seemingly best available material to produce acidity, is toxic in slight excess. It may be necessary to recommend the adjustment of the reaction of the soil in the fields in which the plants are grown during the summer.

Cultures in percolators with constant drip, modified as to reaction with and without iron, gave all pink blooms. The plants had been grown in a soil prepared to produce pink flowers. This is in verification of previous findings that the color of the flowers is governed by the reaction of the soil in which the roots are growing at the time the flower buds are formed.

Culture of Perennials.—Control measures with Iris rhizome rot (*Bacillus carotovorus*) indicate that environmental conditions play a large part in the virulence of the disease. Dahlias were again grown to the number of 428 varieties. In the seedling trial-garden operated in conjunction with the Dahlia Society of New Jersey, 82 seedlings were tested and 28 received certificates.

Tests of the effect of potash on root production gave negative results in our soil. The variety grown was Lady Helen, a notoriously poor root producer. The lack of moisture may have been a limiting factor.

Thrips, which have been seriously damaging dahlias for several years, were controlled by the use of nicotine dusts.

OYSTER RESEARCH

The past season brought for the first time on an extensive scale recognition of the importance of studies of the occurrence of oyster larvae in the water as a guide to shelling. The largest two planters in Barnegat Bay, having together in excess of 100,000 bushels of shells available, volunteered to keep these on the bank until told when to put them overboard. The planters were notified June 8 that a set would occur by the fourteenth. They succeeded in getting their shells planted by the thirteenth. Setting began on June 13 and continued to June 29, planted sheels receiving the heaviest set since 1921.

Shells planted upon the state beds in Delaware Bay and in Barnegat Bay, 225,000 bushels in all, were put down with the advice of Mr. Dumont and of the Biologist. A fair set struck upon the Delaware shells and this lived, whereas the heavy set on the Barnegat shells all died within a few days.

The first week of June, 1925, broke all records for the Weather Bureau. The water of Barnegat Bay rose suddenly to a temperature of 28.5°C (83°F) causing spawning to occur before the germ cells of the oysters had become properly matured. Practically all of the spat which set in June and in early June died before reaching the age of 5 days.

For the first time in scientific oyster investigation oysters were fed upon pure cultures of food organisms by Dr. G. W. Martin, of the University of Iowa, and the rate of growth measured. While the experimental spat did not make as great a growth as those kept under natural conditions it was demonstrated that·some organisms have a distinctly higher food value to oysters than do others.

The temperature at which oysters will spawn has been fixed with considerable accuracy with the aid of a self-registering thermograph which has been in continuous operation on Barnegat Bay for three seasons. After the water reaches 20°C. (68F.) and maintains it for approximately 160 degree-hours, spawning occurs. Spawning is shown to occur also during the first sharp rise in temperature of at least 20°C in magnitude which takes place after the temperature of 20°C. is reached A set may be looked for, therefore, approximately 17 days after the water temperature has reached and maintained 20°C. Since the length of the larval life of the oyster is usually 13 days in New Jersey waters, careful following of water temperature will make possible an increase by several days in the time available for shelling.

Great interest has centered about the opening of the new Manasquan-Bay Head canal through the possibility of opening new areas available for oyster growing at the head of Barnegat Bay. Since Manasquan Inlet promptly closed after the opening of the canal December 15, 1925, the net results has been to add the Manasquan River to the tributaries of Barnegat Bay. Tests made in April, 1920, showed the waters of the canal flowing into Barnegat Bay to be no more salt than those of the bay near Bay Head. Should the inlet be opened and kept so, there may be slight increase in the specific gravity of the waters of upper Barnegat Bay, but this will probably not be sufficient to support oysters on grounds where they do not now occur.

The purpose of the Pennsylvania Railroad to make a solid fill across Barnegat Bay met with decided opposition from oyster growers and yachtsmen at a hearing before the representatives of the War Department in Seaside Park in July. Data based on the records of our self-registering tide guage at Barnegat Pier showed that the expert engineering opinions in the hands of the railroad were based upon false deductions. The railroad company withdrew its application, thus saving Barnegat Bay from the fate suffered by Manasquan; rapid shoaling of the waters due to large areas of still water.

PLANT PATHOLOGY

Potato Spraying.—During the past year meetings have been held in cooperation with the county agents with groups of growers interested in potato spraying. As the result of the activities in this direction, we have records of 20 new sprayers being purchased and used. Five years ago not more than 25 growers in New Jersey sprayed their potatoes. This year, every community has a few growers who are spraying, and, in some sections of the state, nearly every field is being sprayed with Bordeaux mixture.

Certified Seed.—The department has cooperated with the county agents of Monmouth and Mercer counties in maintaining seed-source and variety-test plots and comparisons of certified and non-certified seed potatoes. These demonstrations have led to a much greater use of good seed as is witnessed by the fact that five years ago the dealers of Central Jersey reported that less than 5 per cent of the seed sold by them was certified. This year at least 90 per cent of the acreage in Central Jersey was planted with certified seed potatoes.

Five years ago one sack of seed from Prince Edward Island was included in one of the seed-source test plots. This was the first sack of certified seed planted in New Jersey from this section, and because of its demonstrated freedom from disease, this year approximately 100 cars of seed from this source was planted in the state.

Seed Treatment.—The department cooperated with a number of county agents in conducting seed-potato disinfection demonstrations. As the result of these, the practice of treating seed potatoes before planting is now being generally adopted by the potato growers.

Potato Shows and Tours.—The department assisted the potato growers in their potato show at Trenton during Agricultural Week. Well attended field meetings have been held in Monmouth, Middlesex, Salem and Cumberland counties to explain the potato experiments and demonstrations to the growers.

Experiments and demonstrations with potatoes including seed source and variety tests, fertilizer studies, northern vs. southern grown seed, influence of time of planting late-crop potatoes on vigor, certified seed test plots, scab-control tests, influence of time of cutting on vigor of seed, potato spraying and dusting and degenerative disease studies, are being conducted on 20 farms in the state. These plots vary from ⅛ to nearly 4 acres in size. The experiments are planted and observations made by members of the Department of Plant Pathology. The grower furnishes most of the material and cultivates and sprays the plots as directed. This has proven to be an economical method of conducting the work and at the same time affords an opportunity to show the growers what the station is doing along the lines of potato improvement. This method of conducting the investigations has likewise led to considerable interest among the growers and a more general adoption of the station's recommendations. The change in the potato industry in Central Jersey in the past five years can be cited as an example of this; five years ago approximately 80 per cent of the acreage in this section was planted with the American Giant variety. This potato is very undesirable from the standpoint of quality and a campaign was conducted against it. This year we know of only three farms on which the American Giant variety has been planted.

Seed Potato Improvement.—Considerable work was done last fall with the South Jersey seed growers leading to the improvement of their seed stock. Numerous selection of disease-free Irish Cobblers and Red Skins were made and these are being planted in tuber units, in seed plots. Attention is being given to several of the outstanding strains of potatoes in order that certain growers be instructed in the production of high-grade seed stock to be grown for certification by the remaining growers. This is being accomplished in part by the organization of seed-potato clubs. All of the men in each club are growing a certain strain and the parent stock is being produced by one grower under the direction of the department. This has proved to be an excellent method of maintaining the quality of the seed stock and at the same time has eliminated some of the difficulties experienced in the past in marketing the crop. One club of some 20 members is already in operation, and a second is being formed.

Apple Scab Studies.—Arrangements were made with fruit growers in various parts of the state to send in apple leaves during the critical period for scab infection. These leaves were examined to determine the development of the ascospores and the growers were advised concerning their condition. As the result of this work the growers were better advised concerning the timing of their sprays for the control of scab.

Tomato Wilt Control.—In cooperation with the United States Department of Agriculture, tomato seed of varieties resistant to wilt have been placed on approximately one hundred farms. In most cases these are planted in comparison with the present standard varieties which are known to be susceptible to the wilt organism.

Answers to Inquiries.—During the past year the members of the department have answered over a thousand inquiries concerning plant diseases. Approximately 200 diseases on 83 different species of plant were identified during the year. In addition a large number of personal visits were made on farms at the request of either the farmer or the county agent.

Research Activities

New Methods of Disinfecting Seed Potatoes.—During the past year studies were conducted to determine if some method of disinfecting seed potatoes for the control of scab could be discovered, to replace the present treatment which consists of soaking the seed for an hour and a half in either mercuric chloride or formaldehyde. As the result of these investigations it was found that 2 ounces of organic mercury dust applied to the uncut or 3 ounces to the cut tubers gave as efficient control of scab as the cumbersome liquid treatments. This will effect a considerable saving in time in disinfecting seed potatoes and the simplicity of the treatment will lead to a more general adoption of this important adjunct to successful potato growing.

Studies with seed-borne rhizoctonia indicate also that the use of the organic mercury compounds in either the dust or liquid forms will control this disease as efficiently as the standard mercuric chloride or formaldehyde treatment.

Potato Spraying Experiment.—In a test with the Gold Coin variety at Freehold the average yield of the unsprayed plots was 216 bushels as compared with 293 bushels for those sprayed with Bordeaux mixture. This increase resulted almost entirely from the control of flea beetles and leaf hoppers. In a similar test with the Irish Cobbler variety, the average yield of the unsprayed plots was 193.9 bushels as compared with 247.7 bushels for the sprayed. In this test the use of copper-lime dust gave an increase of only 19.5 bushels over the checks. In a spray test with the Irish Cobbler variety, conducted at Elmer, the average yield of the unsprayed plots was 78 and of those sprayed 5 times with 5-5-50 Bordeaux mixture, 130 bushels per acre.

Influence of Soil Moisture on Rhizoctonia of Potatoes.—Investigations conducted during the past year show that this very serious disease of the potato is much more severe in dry than in wet soils. There is evidence to show also that the losses from the disease may be reduced by shallow planting. These studies clear up a number of troublesome points concerning rhizoctonia and will result in recommendations which will lead to a reduction in its prevalence.

Northern vs. Southern Grown Seed Potatoes.—This work, conducted in cooperation with Prof. Wm. Stuart of the United States

Department of Agriculture, furnished conclusive proof that as vigorous seed potatoes can be produced in South Jersey as in Maine. Comparative tests of Maine and New Jersey grown seed have been conducted for three years in Maine, Connecticut and New Jersey. In Maine the average yield of the Maine-grown seed was 315.3, and of that grown for one year in New Jersey, 312.4 bushels per acre. In Connecticut the average yield of the New Jersey grown seed was 211.1 and of the Maine grown seed 206.7 bushels per acre. In New Jersey the average yields were 109.6 and 113.9 for the Maine and New Jersey grown seed, respectively. These tests showed also that the same strain of seed may be grown for more than one year in New Jersey without loss of vigor as compared with the same strain in Maine.

The results indicate that when potatoes are planted in New Jersey as a late crop and the necessary measures are adopted for the elimination and control of diseases, the potatoes produced are as vigorous for seed purposes as those grown in the northern states.

Investigations of Apple Blotch.—Studies conducted within the past year indicate that blotch infection takes place at an earlier date than was formerly supposed. First blotch infection was observed on May 26; the trouble did not become general, however, until June 8. In the orchard where this work was conducted, only 11.5 per cent of the fruit was clean on unsprayed trees. On trees sprayed with concentrated lime-sulfur 48.1 per cent of the fruit was free from blotch, while where summer applications of 2-4-50 Bordeaux mixture were made the amount of clean fruit was increased to 77.6 per cent. The work on this disease has progressed far enough now so that if the recommended treatment is adopted a clean crop may be grown in orchards where previously a considerable portion was rendered unsalable by this very serious disease.

Investigations of Apple Scab.—Studies conducted to determine the time of infection of the apple scab organism show that in New Jersey we cannot expect any infection prior to the regular pink-spray application. In the spring of 1926 the heaviest discharge of ascospores, and consequently the heaviest infection of scab took place at petal fall. These studies showed also that spore discharge took place only during periods of rainfall. Preliminary studies indicate that temperature plays an important role in the development of the ascospores, no development taking place at high temperatures. These results are of value in assisting the growers in the timing of their spray applications.

In comparative tests with various spray and dust materials for the control of scab, 50 per cent of the leaves on unsprayed trees were infected as compared with 0.6 per cent on trees sprayed with colloidal sulfur and 0.5 per cent on those sprayed with Dry-Mix.

Sweet Potato Disease Investigations.—Results of investigations on the control of sweet potato scurf and pox, two very serious diseases of this important crop, showed that an application of 300 pounds of sulfur, made before the sprouts are set out, will result in a clean crop. Studies on stem rot showed that the use of resistant varieties, such as the Red Brazil, Yellow Yam, White Yam and Triumph, is a satisfactory method of reducing the losses resulting from this disease.

Results of tests with varieties susceptible to stem rot, such as the Porto Rico and the popular Yellow Jersey strains, showed that a nearly perfect stand could be had by planting two or three sprouts per hill as compared with a stem-rot kill varying from 5 to 50 per cent where one plant was set. The use of the two or three plants also gave an increase of from 30 to 50 per cent in production.

Studies on Spray Injury to Peach.—A large number of modifications of New Jersey Dry-Mix and other sprays were again tested this year to determine the cause of spray injury to peach trees. As in former years, the injury proved to be due to the arsenical contained in the mixture. By reducing the lead arsenate to 1 pound per 50 gallons standard Dry-Mix, the injury was practically eliminated. As a result of these tests our spray recommendations have been so modified that no spray injury occurs where the recommendations are carefully followed.

Pea Root Rot.—Studies on the root rot disease of garden peas caused by *Aphanomyces cuteiches* have given information which will aid materially in reducing the losses from this disease. As a result of variety tests for susceptibility to root rot, two varieties, viz., World's Record and Sutton's Ideal, which several years ago were scarcely known in this state, have become very popular among most of the pea growers in the root-rot areas. On severely infected soils these two varieties have uniformly given better yields than the varieties formerly grown.

The discovery of a number of new host plants which may aid the root rot organism to tide itself over from season to season and to increase itself between pea crops, adds a new angle to the question of root-rot control. Since a successful rotation should exclude all the hosts of the organism, our recent results will help materially in working out a satisfactory rotation for soils infected with the root-rot organism. Some of the crops which have been shown to be subjected to attack by *Aphanomyces cuteiches* are garden peas (all varieties), Canada field peas, sweet pea, cowpea and winter vetch. The oogonia of the organism have also developed normally in dead parts of crimson clover, navy bean, red kidney bean, spinach and timothy. It seems evident that the decaying parts of these plants may act as a suitable substratum for the saprophytic development of the root-rot organism in the soil.

Eggplant Wilt Studies.—The experiments on the effects of soil applications of lime and sulfur on development of eggplant wilt showed a partial control of the disease on plots which had been acidified with sulfur. Where green manures were used in addition to sulfur the control was somewhat better than where no green manure was added. Lining the soil greatly increased the losses from the wilt disease. On July 3, for example, the plots receiving 1000 pounds per acre of hydrated lime showed 55 per cent diseased plants on the green-manured section, and 80 per cent on the part receiving no green manure. On the block receiving 600 pounds of sulfur per acre the proportion of plants showing wilt on this same date was 20 per cent for the green-manure section and 30 per cent for the unmanured portion. The growth of the plants as indicated by height was greater on the sulfured blocks and less on the limed blocks. The average height of the plants for the blocks receiving 1000 pounds of lime, 500 pounds of lime, no treatment, 300 pounds of sulfur and 600 pounds of sulfur per acre, was 16.85, 17.55, 18.2, 19.05 and 19.65 inches, respectively. Furthermore, the limed block yielded no remarkable fruits, while a fair crop was realized on the check and the sulfured blocks.

Other Activities

The plant pathologist acted as chairman of the Seed Potato Certification Committee of the Potato Association of America. A set of nuiform rules and regulations governing certification were submitted at the annual meeting of the association and adopted by a majority of the states offering this service. In order to bring about a greater uniformity in the interpretation of the rules and regulations and particularly to have uniform inspection service in all of the states, a conference of the seed potato certification authorities was held at Freehold. This was attended by pathologists from Maine, New York, Vermont, Pennsylvania, District of Columbia, Michigan, Virginia, Canada and Bermuda. The conference was a decided success and will unquestionably result in considerable improvement in certification methods. In continuation of this work plans are being formulated to protect certified seed potatoes from fraud.

The plant pathologist also acted as chairman of the New Jersey Potato Improvement Committee, consisting of a representative of the bankers, potato dealers, growers, State Department of Agriculture and Farm Bureau Federation. Considerable time was spent in work with the growers and dealers in an effort to improve the potato crop. Attention was given to the use of better seed, spraying, proper cultural conditions, and particular attention was given to better grading of the crop. A number of meetings were held with the dealers who contributed funds to employ loading point inspectors. This intensive educational campaign resulted in a decided improvement in the quality of Jersey potatoes and was the means of impressing the growers with the need of adopting the modern, approved practices of potato growing if they are to be successful with the crop.

This committee has been continued along slightly different lines. A 300-bushel club has been organized, the members to include those growers who produce 300 bushels of U. S. Grade No. 1 potatoes on a 5-acre block. Through this work the committee hopes to further impress the growers with the need of adopting the best potato-growing practices.

The plant pathologist served as associate editor of *The Potato Journal.* This is published by the Potato Association of America and is received by a large number of farmers in the United States and Canada. As collaborator of "Botanical Abstracts" he abstracted the New Jersey Experiment Station publications, including bulletins, circulars and annual reports. During the year the members of the department addressed 30 meetings. These were attended by 2,444 growers.

PLANT PHYSIOLOGY

The research activities of the department of plant physiology during the past year were devoted chiefly to the following lines of investigations:

Iron availability and mobility in plants.

The relation between the vegetative pigments (chlorophyll, carotin, and xanthophyll) and the physiological activities and yield in corn.

Correlation studies between morphological characters and yield in wheat.

Studies on the stimulatory effect of boron upon plants in solution cultures.

The effect of seed mutilation and initial food reserve on the efficiency indices of the plants.

Considerable progress has been made during the year in all these lines of investigation and, on the whole, the results of the year's work have been gratifying.

The work on the iron project has brought out some very interesting and important relations. It has been found that the reaction of the plant juices bears a direct relation to the mobility and distribution of iron in the plants. Plants, such as buckwheat and oxalis, whose juices show pH. values considerably below the precipitation point of iron, have no difficulty in obtaining from growth media and distributing sufficient iron to insure normal production and proper functioning of chlorophyll in the leaves. On the other hand, iron mobility and proper distribution is rendered difficult when the reaction of the plant juices lies close to the precipitation point of iron, as it does in such plants as corn and soybeans. Under such internal conditions, the reaction of the medium in which the plants are grown becomes an important factor. These relations may explain the occurrence of certain pathological phenomena on soils which have received special fertilizer treatments, such, for example, as the occurrence of "lime induced" chlorosis in some plants and not in others on limed soils. The relation of iron mobility to reaction of plant juices and growth media has been studied in connection with a few of the agricultural plants only. Thus far it appears that each species presents its own peculiar iron problem.

Studies on the relation between vegetative pigments, leaf area, and dry-weight yields in corn have been continued during the year. Thus far no clear relation has been found between growth rates and pigment content expressed either on the basis of unit area of leaf surface or unit weight of dry leaf substance. However, in comparing different varieties on this basis, it was found that those having relatively high chlorophyll and certain content per unit of leaf area or per unit of weight, invariably produced higher yields than did those with relatively lower pigment content measured on the same basis.

During the past four or five years, data have been collected from three varieties of wheat grown in different climatic regions over several crop years for the purpose of making correlation studies between morphological characters and yields and of determining the physiological causes underlying certain relatively stable correlations, and how these could be used in predicting grain-yielding ability. In contrast to previous investigations of a similar nature, crops were grown in the drilled row with normal rates of seeding, and the unit of area was used as the basis for calculating correlation coefficients. These studies have brought out the fact that correlations must prove stable before they can be used with any degree of accuracy in predicting yields. The use of formulae involving the number of spikes and the factors expressed as "gram yield per spike" usually prove unreliable in predicting grain-yielding ability, and this indicates that probably the best method of selecting high-yielding strains is still that of careful field-plot testing over a series of years.

During the year a study was begun involving the investigation of the responses of the broad bean (*Vicia faba*) to boron in culture media. Recent investigations at the Rothamsted Experimental Station have suggested that perhaps boron is an essential element for the growth of this plant. However, data obtained here, although the work has not yet progressed very far, indicate that the maximum stimulatory effect of boron in growth media decreases as the efficiency of the media increases for producing good growth, and that entirely normal healthy plants can be grown in the absence of boron by selecting the properly balanced culture solution. This work is being continued.

Work on the seed-weight project involving the determination of efficiency indices of several species grown under different experimental conditions, has been resumed. This work has not progressed sufficiently as yet to warrant a statement in regard to the effect of seed mutilation on the efficiency indices of plants grown from mutilated seed.

POULTRY HUSBANDRY

The activities of this department can be summed up under the following headings, Research, Egg Laying Contests, and Administration of the Exhibition Fund.

New Jersey Egg-Laying Contests

Beginning November 1, 1925, the Vineland Egg Laying Contest was turned into a one-year contest, on the same basis as the Bergen County contest For the year beginning November 1, 1924, and ending October 31, 1925, the birds at the Vineland Egg-Laying Contest made an average production of 128.2 eggs, and for the same period the birds at the Bergen County Egg-Laying Contest made an average of 144.4 eggs.

During the past year it has been necessary to do considerable repairing at both contests, and a special appropriation from the Legislature for the amount of $6,000, is being used to partially cover the labor and necessary equipment for placing the contests in good condition.

Poultry Exhibitions and Shows.—During the past year the amount of $6,000 was made available by the Legislature for the purpose of paying premiums at poultry shows. The following shows received from $300 to $800 each for this purpose:

Trenton Fair Association Poultry Show
Flemington Fair Association Poultry Show
Atlantic County Fair Association Poultry Show
Vineland Poultry Association
Essex County Poultry Association
Middlesex County Poultry Association
Sussex County Fair Association
Morristown Poultry and Pet Stock Association
Gloucester County Poultry Association
Mercer County Poultry Association
Hackettstown Poultry Association
Riverside Poultry Association

Research

Laboratory of Poultry Pathology.—A total of 1423 cases were handled in the poultry pathology laboratories. Of this number 760 were handled by the examination of diseased fowls, 391 cases by letter, 33 cases from the College Farm, 105 cases from the Vineland Egg-Laying Contest, 25 cases of disease in cage and ornamental birds, and 3 cases by telephone. In the course of the year 106 visits were made to farms affected with disease. A total of 2322 specimens were autopsied, and in them 3470 diseases were found.

A total of 52,886 blood samples were tested. Of this number 52,680 were made on fowls for the control of Bacillary White Diarrhea, and 206 tests were made on cattle for Infectious Abortion.

Experiments relative to the practical administration of Kamala (a tapeworm treatment) are being made at Vineland. Particular attention is being paid to the effect of this drug on birds chronically parasitized or affected with secondary conditions. Experimental chicks are also being fed with many kinds of possible intermediary hosts suspected of being carriers of tape worms.

A parasite affecting the proventriculus has been encountered on several occasions and an attempt will probably be made to find its intermediate host. A similar parasite affecting aquatic birds is carried by a water crustacean to which observed infested fowls could not have had access. A paratyphoid infection in the common fowl has been determined and will be studied in comparison with other types under avian paratyphoid organisms. Progress is being made in determining the extent of this type of infection. A number of outbreaks have been determined in cage birds and one outbreak in pigeons. This suggested the possibility of its occurrence in the domestic fowl and during the past year two such outbreaks have been found. The organisms are being studied in comparison with types from various hosts.

The study of the relation of soil reaction to the infectious poultry disease organisms has demonstrated that the fowl typhoid organism (*Bacterium sanguinarium*) will not live for a week in soil as acid as pH 6.2 or lower. At pH 7.0 the organism is still viable after sixteen weeks.

One phase of the study of *ascaridia perspicillum* has been completed. An experiment to determine the effect of the common disinfectants on the embryonated eggs in soil showed that a 5 per cent solution of phenol was effective when used at the rate of 1 gallon to 10 square feet. A 1 to 1000 solution of bichloride of mercury, a 5 per cent solution of formaldehyde and 5 per cent solution of hydrochloric acid used at the same rate failed to destroy the eggs of *A. perspicillum.*

Experiments are being conducted on the rearing of fowls in confinement for the prevention of all intestinal parasites. Ground infection is prevented by keeping the birds entirely off the the ground by means of a concrete slab extending out 10 feet from the brooder house. Prevention of tapeworm infestation is effected by enclosing the concrete runs with fly screen. Lots of chicks reared on concrete with and without screening and also on the ground by the usual methods will be placed under respective conditions in laying quarters so that a study may be made of the effect of such rearing on egg production, disease, etc.

Other Projects.—One of the main projects which has been carried on at this station for the past two years, along nutritional lines, has been the influence of feeding a fungus enzyme on production and growth of poultry. A part of this work was reported in the annual report for 1925. Since that time work has been done on layers, which has indiacted that there is a favorable result from the feeding of this material to layers at the rate of 3 per cent in the mash. During the spring of 1926 some of the work carried on last year relative to the feeding of enzymes in the growing of young stock has been repeated. The results indicate, as they did last year, that under average conditions the addition of approximately 3 per cent protozyme in the mash will have a favorable effect on the growth of chicks for the first six or eight weeks.

Another project which was carried out during the past winter had to do with the effect of using electric lights on laying birds. It was found that greater production resulted in the pen in which lights were used. There was also less molting. There seemed to be a slight loss of weight per bird in the pen where lights were used compared with the check pen where no lights were used, which would indicate that more work should be done to determine whether it is possible to maintain body weight and at the same time increase production with the use of artificial light.

A test was run in comparing two dry mash mixtures for laying hens, with the object of ascertaining whether it is possible to simplify the New Jersey dry mash. It would appear that a simpler dry mash can be made up for laying birds with fully as good results as those containing the wider range of ingredients.

A comparison was made of three sources of animal protein for the purpose of determining whether there is any advantage in feeding a higher protein meat scrap to poultry. From the results obtained during the first five months, it would seem that there is practically no difference between a high protein meat scrap and a regular 50 per cent meat scrap, when the nutritive ratio of the mash remains the same.

SEED CONTROL

The seed control laboratory has carried on its two main lines of work, much as it had in previous years, namely, the analysis of so-called official samples of seed and the analysis of unofficial samples. Seed samples have been collected from all local dealers in the state. The crop samples have been analyzed for purity and germination and a report of the laboratory findings given to the dealer. Vegetable seed samples have been analyzed for germination and a report made to the local vendor. These samples represent the type and quality of seed sold to the general public in the open market, constituting the official inspection. As this is not completed until the end of the year, the report is made at a later date, giving complete results for the year. To date approximately 1500 samples have been drawn and analyzed by the laboratory.

The testing of unofficial samples has long been the popular phase of the laboratory activity. Unofficial samples are those sent in for analysis by farmers, growers and dealers. This service is rendered by the seed laboratory free of charge and is considered very valuable to the agricultural industries of the state. Any resident can send to the laboratory any kind of a seed and ask for an identification, a purity or germination analysis, weed-seed content, crop-seed content or a general statement of value for seeding purposes. This feature of the laboratory's activities requires the greater part of the time of three analysts. The reports made to the sender are detailed and give purity percentages, weed-seen content, germination, etc. There is a constant increase in the numbers of requests for this service due, no doubt, to previous educative measures and to the benefits which those who have availed themselves of the opportunity have gained.

As requests for analyses increase, the equipment and number of analysts must increase in proportion. Another full-time assistant was added to the force this year. A total of 2916 samples, or over 8000 determinations, have been made during the last fiscal year. These samples represent practically as many lots of seed held in storage for planting. A large percentage of these samples are vegetable seeds, but many are fancy lawn and turf mixtures requiring much time and training and technical knowledge on the part of the analyst to determine the kinds and percentages of the various ingredients. A number of golf course mixtures have been analyzed. Large numbers of lawn grass samples have also been examined. The convenience of having samples of seed analyzed and the knowledge of their quality and viability previous to planting is of inestimable value to the inquirer.

In addition to seed identification the department makes weed identifications also. A record of these specimens is kept in the laboratory files so that a weed infestation can be traced wherever it occurs.

The department also carries out the provisions of the Legume Inoculant Law which governs the sale of inoculants for legumes. Samples of these materials are secured from the stock of retail vendors throughout the state. They are analyzed both for the specific organisms they may contain and for their adaptability to special legume plants. A detailed report of the findings of each sample is returned to the vendor. In addition to the official testing of legume inoculants there has been this year some unofficial work in the testing of samples used for experimental purposes.

SEWAGE RESEARCH

With the progress made from year to year on fundamental studies of the biology of sewage disposal it becomes more apparent that the information gathered will ultimately lead to decided improvement of existing systems of sewage disposal. It also paves the way for new, thoroughly understood methods. Considerable information has been obtained during the last fiscal year on the effect of environmental conditions on the speed of sludge digestion and the feasibility of controlling these conditions. Particular attention has been paid to the influence of reaction of the material and the effect of temperature on the rapidity of digestion. Information relating to these two factors is extremely meager or totally absent. The fact that with a certain adjustment of the medium the time of digestion is reduced and the type of digestion is influenced or can totally be changed is ample evidence that the possibilities of improving existing systems and the establishing of new methods of anaerobic digestion are real. These questions are no longer in the realm of speculation. We are on the threshold of a new phase of sewage disposal, namely, that of scientific control. In connection with scientific plant control it may be recorded that aside from the most fruitful cooperation at the Plainfield plant we have begun cooperative experiments on separate sludge digestion, on a large scale, with the City of Baltimore at its Back River sewage disposal plant.

The sewage laboratories established by an act of the New Jersey Legislature in 1920 as a joint project between the New Jersey Agricultural Experiment Station and the New Jersey State Department of Health will be expanded at the end of the fifth year into a Department of the Biology of Sewage Disposal of the New Jersey Agricultural Experiment Station. During these five years the New Jersey Sewage Works Association has been in close contact with the work of the sewage laboratories. Some of the experimental results secured may be briefly described as follows:

Effect of Lime on Sludge Digestion

Optimum Reaction

1. Poorest digestion prevails when materials in tanks are slightly acid or very alkaline.
2. Different reactions influence digestion differently.
3. "Liquifaction" and "gassification" can be induced by certain reactions.
4. Best results are obtained with reactions of pH 7.3—7.6.

Effect of Lime

1. Lime influences the flora and fauna of sewage solids and consequently the chemical intermediate and end products.
2. Lime changes the physico-chemical relation in sewage solids so that the solids are differently distributed in the liquid phase with different reactions.
3. In general lime additions up to a certain point stimulated the numbers of bacteria, but maximum numbers do not necessarily mean maximum digestion.
4. With higher reactions (above pH 7.6) great fluctuations in bacterial numbers occur, indicating a condition of unstability. At these higher reactions odors enamating from the digesting material are stronger and more offensive.
5. If the reaction of incoming fresh solids is kept at pH values of 7.3—7.6, odors are practically absent.
6. The numbers of protozoa decrease markedly when the reaction of the digesting material is changed from pH 7.2 to 7.6, and higher reactions cause alternating rapid increases and decreases in numbers, but variation in pH values between 7.2 and 8.8 had no effect on the variety of species.
7. Daily additions of fresh solids kept at pH values of 7.3—7.6 can be increased from 2 to 3.5 per cent dry solids.

Imhoff Tanks

A comparison of two Imhoff tanks, one treated with lime to adjust the reaction of its contents and the other untreated, showed that the treated tank gave no sign of foaming and was free from scum for several months in spite of the fact that it was continuously operating, whereas the untreated tank had to rest and could not be put into operation for a long time on account of heavy foaming.

Separate Sludge Digestion

Experiments on separate sludge digestion were conducted during the period October 14, 1925, to April 16, 1926, on a tank with a capacity of 25,000 cubic feet and equipped with a floating cover. Results show that during this period such a tank can handle about 100,000 cubic feet of fresh sewage solids of a 5 per cent solids concentration, provided the relation between fresh solids and ripe sludge is kept in the correct proportions (additions daily of 2 per cent fresh solids on a dry basis) and the incoming material is adjusted with hydrated lime to a definite reaction of pH 7.3.

Figures over several years on the Plainfield plant show, that the digestion compartment of an Imhoff tank required to treat the same quantity of solids in the same time is 56,000 cubic feet.

Amounts of Lime Necessary

1. Lime, if needed, should be added daily to fresh solids in separate sludge digestion tanks and is preferred for Imhoff tanks because it is more economical and better results for digestion are obtained.
2. The amount of lime necessary to adjust the Plainfield fresh sewage solids to pH 7.3 is from 3 to 4 pounds per million gallons daily; to adjust them to a pH value of 7.6 about 25 pounds per million gallons daily.
3. Data are obtained and plotted to show the amounts of lime necessary to adjust the reaction of incoming fresh solids of different solids concentrations.

Effect of Temperature on Digestion

1. The effect of raising the temperature a few degrees above a minimum of 50°F is comparatively slight.
2. Digestion time is materially decreased with higher temperatures.
3. Optimum temperature for rapid and efficient sludge digestion is about 80°F. (Average temperature during the year in the digestion chamber of Imhoff tanks at Plainfield is 59°F, highest 74°F, and lowest 48°F. Temperature is 5½ months below the average).
4. A definite amount of organic matter produces a given amount of gas irrespective of temperature.
5. The amount of gas produced from a definite amount of organic material *in a given period* depends upon the temperature.
6. Gas production and composition of gas is influenced by the reaction of the medium.
7. Under certain conditions, which are entirely practical, the rate of gas production can be speeded up from 5 to 10 times.

Optimum Reaction and Temperature

1. Optimum reaction and optimum temperature together increase the rate of digestion more than one of the two alone.
2. Exclusion of air induces "liquifaction" and increases the rate of solids reduction. This liquifaction can be changed by proper reactions and proper temperature to gassification.
3. Lime, at lower temperatures (50-60°F.) retarded the death rate of the *B. coli* group.
4. Lime, at higher temperatures (75-95°F.) accelerated the establishment of spore-forming anaerobic organisms.

Studies on Film Accumulation in the Filter Beds.—Data collected on old and new films throughout one year showed fluctuations, but there is a general trend. The average amount of wet film deposited upon a tile each week weighed approximately 3.5 gm. with a variation of 2 to 5 per cent solids (average 4 per cent). The rate of film deposit was not uniform throughout the bed in regard to total deposit amount of solids and percentage ash.

The older film showed a fluctuation with gradual increase in solids content from one sloughing period until the next, with an increasing percentage of ash.

The action and efficiency of new and old film throughout the bed changed according to its accumulation.

It is suggested that the design of a filtered-bed should depend on the amounts of solids to be handled. It will be a question of economics whether more area or more depth is desired.

Distribution and Succession of Protozoa in Imhoff Tanks

1. Flagellates are far more numerous than ciliates in Imhoff tanks.
2. Vertically, flagellates are present in maximum numbers usually between 5 and 7 feet. There is no definitely located point for the ciliate maximum.
3. Numbers of protozoa are independent of observed range of H-ion concentration and temperature in the tanks.
4. There is definite relation between large increases in numbers and foaming.

Effect of Chemicals on Digestion

1. Small quantities of lime hasten digestion processes; larger quantities retard digestion, the greater the amount added the greater the retardation.
2. Sodium nitrate proved beneficial, the more sodium nitrate added the more rapid was the digestion.
3. Soduim sulfate, in the amounts used, hastened digestion, but considerable odor was caused by the libertion of hydrogen sulfide gas.
4. $CaHPO_4$ is of no value for increasing the rate of digestion.

Study of Material Suspended in the Liquid Above

Decomposing sewage sludge.—An experiment was run to determine the source, the identity, and the changes taking place in the character of the material suspended in the liquid above digesting sewage sludge. The following conclusions are drawn:

1. During the first stage of decomposition the major portion of the suspended matter is finely subdivided carbonaceous material, probably cellulose.
2. The fine state of subdivision is accomplished in the sludge layer during acid digestion, and the material is transferred to the liquid layer by gas bubbles. It remains suspended because its density is practically the same as that of the liquid.
3. This carbonaceous material is returned to the sludge layer by flocculation and the rest of the suspended matter is decomposed in the liquid in a manner similar to the decomposition in the sludge layer.

SOIL CHEMISTRY AND BACTERIOLOGY

Field Experiments.—Nitrogen availability studies have been continued on the original 40 plots. The crop this year is timothy.

As a source of material for chemical, physical, and bacteriological studies the soil from these plots is particularly valuable. Other field experiments that have been continued are those dealing with magnesian and non-magnesian limestone, those with legume and non-legume green-manure crops, and some work with concentrated fertilizers.

Two new cooperative experiments have been started, one in Burlington County and one in Monmouth County. The Burlington County experiment has for its object a study of the amounts of fertilizer and methods of applying fertilizer for sweet corn. The Monmouth County experiment is similar to the one in Burlington County, but includes tomatoes as well as sweet corn.

Potato Experiments.—The work on amounts of fertilizer, sources of nitrogen and amounts of potash for potatoes in cooperation with J. Harry Kandle at Elmer has been continued. This year will complete 10 years of work on this project. Due to the dry weather and diseased condition of the vines, last year's results were of less value than those of any previous year.

In addition to this work a field experiment is being conducted at the station for the purpose of determining the proportion of phosphoric acid that will give best results with potatoes. Also the cooperative work with the Bureau of Plant Industry of the United States Department of Agriculture and the department of plant pathology on fertilizer ratios for potatoes (triangle experiment) has been continued.

Cylinder Experiments.—The cylinder experiments have been continued in the same manner as last year. They include studies on the availability of nitrogen in fertilizer materials with a constant supply of phosphoric acid and potash, and also with varying quantities of these materials. A comparative study is being made on three types of soil, of acid phosphate and rock phosphate for potatoes. Also some work is being carried on in the cylinders with concentrated fertilizers.

Microbiological Studies.—Studies have been continued on the origin of humus in the soil and the microorganisms concerned in the transformation of the natural organic substances and chemical processes involved. Of the different groups of microorganisms, the actinomyces were found to be most active in the decomposition of soil organic matter. A detailed study of the origin of peat is also being undertaken.

A study of the catalytic power of the soil as an index of microbiological activities in the soil brought out certain interesting relationships.

Base Exchange Studies.—Investigations have been under way on soil colloids and base exchange. The role of iron and aluminum irons in the soil has been under special investigation.

An attempt is being made to separate, by dialysis, the crystalline and colloidal substances in the soil. Quantitative determinations have been made on the unsaturated condition of some of the plot soils with special reference to the problem of soil acidity. Methods have been worked out for such determinations and a partial report published.

Work on the base exchange capacity of the soil from certain of the plots and from areas in the state is progressing favorably. An attempt is being made to correlate this work with crop yields from the soil fertility plots.

Studies on Aluminum Toxicity.—In connection with the availability studies on sulfate of ammonia, laboratory and greenhouse experiments have been made with a view toward determining to what extent sulfate of ammonia, sulfur and sulfuric acid cause aluminum compounds to go into solution in the soil. This work has involved a large number of aluminum determinations. A report will be published later.

Work on Methods of Analysis and on Miscellaneous Samples.—In addition to making a large number of nitrogen determinations, which come as a part of the nitrogen availability work, Mr. Prince has again served as associate referee on nitrogen for the Association of Official Agricultural Chemists and has made some contribution to the work on methods of analysis.

Lime-requirement determinations have been made on a large number of samples and a number of miscellaneous samples have been identified. Also some miscellaneous work has been done for other departments.

PUBLICATIONS

The duties having to do with publicity and publications in both research and extension are consolidated in the department of publications. The activities for the fiscal year 1925-26 are classified under the two divisions indicated.

Research

The department has served the research program of the institution mainly through the regular Experiment Station publications. A list for the year is appended. These publications have attained a wide circulation. There are now 17,000 addresses on the mailing list. In addition to the mailing list circulation the department distributed large numbers in response to special requests. During the period from March 16 to April 30, when a record was kept, 691 publications per day on the average were mailed from the department in response to special requests and for distribution through county agricultural agents.

In addition to the regular university publications, the international journal, *Soil Science,* has been edited in the department.

Most of the station bulletins, circulars, reports and also *Soil Science* have been handled by the assistant editor.

The editor has conducted a research study in the agricultural history of New Jersey. This will probably be published as a station bulletin during the next year.

The members of the editorial staff attended the annual conference of the American Association of Agricultural College Editors at Raleigh, N. C., in July, 1925. A paper on county agent departments in local newspapers was given by the associate editor, and a paper on the history of agricultural publications in New Jersey by the editor. An exhibit of New Jersey publications was entered in the annual exhibitions of the association.

The department handled the publicity for the annual Field Day held June 16. News about the meeting was published widely throughout the state, and doubtless was responsible in a large degree for the record attendance.

The multigraph service maintained by the department has been used very widely by the different departments of the institution, and has demonstrated its utility and economy.

Extension

The department of publications rendered service in extension instruction mainly through its publications, the regular series being extension bulletins and "New Jersey Agriculture." The department also issued a weekly news service of extension material to the press of the state, to the dailies of New York and Philadelphia, and to the farm papers of the East. Material thus issued has had wide circulation. Observation indicates that the papers used a larger proportion of publicity matter from the Experiment Station this year than ever before. By cooperative arrangements with the county agricultural agents much of this material was handled by the agents for their local newspapers. Through the assistance of the department the county extension agents conducted regular columns or departments in 60 newspapers of the state. The department kept in touch with the extension agents through a publicity letter sent at intervals under the title "Spreading the News."

Special assistance has been given the Hunterdon County Board of Agriculture in organizing a publicity campaign for the appointment of a county agricultural agent.

These extension activities were largely in charge of the associate editor. As chairman of the Committee on Exhibits, he supervised the university exhibit at Agricultural Week, Trenton, in January. His committee also arranged a university exhibit at the South Jersey Exposition at Camden which opened July 1.

The fourth annual Newspaper Institute was held at the University September 28 and 29, 1925. The editor was chairman of the committee in charge. The institute was the most successful ever held, from the standpoint of attendance, interest shown and quality of program. There were 126 regularly registered delegates and the total attendance was estimated at about 200. Special features of the institute were the competitive newspaper exhibit judged by Prof. Bristow Adams, of Cornell University, addresses by prominent journalists, and a New Jersey grown dinner served by the Home Economics Department of the College for Women.

Publications Issued

Bulletins

416 Agricultural Production and Marketing in Atlantic County, N. J. W. C. Funk, A. G. Waller, A. R. Eldred, Henry Keller, Jr.
417 Studies on the Biology of Sewage Disposal. The Fauna of Imhoff Tanks. J. B. Lackey.
418 Shucking Oysters: One of New Jersey's Growing Industries. Wm. H. Dumont.
419 A Study of the Chemical Factors Involved in Arsenical Injury of Fruit Trees. Nico Mogendorff.
420 The Injurious Effect of Submergence on the Cranberry Plant. S. Wakabayashi.
421 Nitrogen Availability Studies on Crops Harvested at Different Stages of Growth. G. H. Singleton.
422 Analyses of Commercial Fertilizers, Fertilizer Supplies, and Home Mixtures—1925. Charles S. Cathcart.
423 Relation of Summer Rainfall to Mosquito Prevalence. T. J. Headlee.
424 Analyses of Materials Sold as Insecticides and Fungicides During 1925. C. S. Cathcart and R. L. Willis.
425 Bacillary White Diarrhea Control in New Jersey, 1924-25. F. R. Beaudette and J. J. Black.
426 Analyses of Commercial Fertilizers and Ground Bone, 1925, Analyses of Agricultural Lime. C. S. Cathcart.
427 Studies on the Biology of Sewage Disposal. Fourth Annual Report of Sewage Substation for the Year ending June 30, 1925. W. Rudolfs, et al.
428 Results of Seed and Legume Inoculant Inspection, 1925. J. G. Fiske.
429 Creamery Inspection in New Jersey. Sixth Annual Report. George I. Ball.
430 More Lime Needed for New Jersey Farms. A. W. Blair.
431 Fertilizer Registrations for 1926. C. S. Cathcart.
432 Spring Cauliflower in New Jersey. Howard F. Huber.
433 Cultural Methods for Reducing Losses from Sweet-Potato Stem Rot. R. F. Poole.
434 Relation of the Honey Bee to Fruit Pollination in New Jersey. Ray Hutson.
435 Analyses of Commercial Feeding Stuffs and Registrations for 1926. C. S. Cathcart.
436 Relation of Soil Nitrgoen to Nodule Development and Fixation of Nitrogen by Certain Legumes. C. G. Giobel.

Circulars

178 Vegetable Plant Lice. T. J. Headlee.
179 Insect Pests of Boxwood. Clyde C. Hamilton.
180 1926 Spray Calendar for Apples and Quinces.
181 1926 Spray Calendar for Peaches.
182 1926 Spray Calendar for Plums and Cherries.

183 1926 Spray Calendar for Grapes.
184 Peonies in the Garden. Charles H. Connors.
185 Pansies from Seed. Charles H. Connors.
186 Practical Methods of Sampling and Testing Milk, Cream and Ice Cream. H. C. Moore and G. I. Ball.
187 The European Red Mite. Clyde C. Hamilton.
188 The Eastern Tent Caterpillar. Clyde C. Hamilton.
189 Better Milk from Cleaner Cows for New Jersey. H. C. Moore.
190 Preparation of Bordeaux Mixutre.
191 Cherry Leaf Spot.
192 Potato Blights.
193 Tomato Leaf Spot.
194 The Melon Blights.
195 Celery Blights.
196 Maple Leaf Scorch.
197 Horse-Chestnut Leaf Blotch.
198 Special Circular of Information for Spraying for the Season of 1926.

Extension Bulletins

47 Dairy Farm Devices. J. W. Bartlett and E. R. Gross.
48 Vegetables as Food. Marie C. Doermann.
49 Floors—Their Finish and Care. Mrs. M. C. Bell.
50 Local Leadership and the Effectiveness of Extension Work in Reaching Rural People. H. J. Baker and M. C. Wilson.
51 Plant-Growing and Plant Growing Structures. C. H. Nissley.
52 A Septic Tank. E. R. Gross.
53 Home Demonstration Work. Marion Butters.
54 Better Lawns. H. R. Cox.
55 Soybeans for New Jersey. H. R. Cox.
56 Canning Vegetables and Fruits for Winter. Marie C. Doermann.
57 The Pruning of Young and Bearing Peach Trees in the Orchard. M. A. Blake.

New Jersey Agriculture

Vol. 7, No. 7-12.
Vol. 8, No. 1-6.

Hints to Poultrymen

Vol. 13, No. 10—The Problem of Maintaining Body Weight. C. S. Platt.
Vol. 13, No. 11—Producing Market Eggs of High Quality. C. S. Platt.
Vol. 13, No. 12—Ventilation for the New Jersey Poultry House. E. R. Gross.
Vol. 14, No. 1—Common Disinfectants and Their Use. F. R. Beaudette.
Vol. 14, No. 2—Selection, Care and Management of Breeding Stock. C. S. Platt.
Vol. 14, No. 3—Report of Egg-Laying Contests for 1924 and 1925. Martin Decker.
Vol. 14, No. 4—Egg Production, Monthly Costs and Receipts on New Jersey Poultry Farms. W. H. Allen.
Vol. 14, No. 5—Good Incubation Practices—R. R. Hannas.
Vol. 14, No. 6—Practical Control of Intestinal Worms. F. R. Beaudette.
Vol. 14, No. 7—Green Feed for Poultry. L. G. Schermerhorn.
Vol. 14, No. 8—Special Crate Fattening of Poultry. Martin Decker.
Vol. 14, No. 9—Capons in New Jersey. L. M. Black.
Vol. 9, Nos. 8, 9, 10—(Reprints.)
Vol. 10, No. 8—(Reprint.)
Vol. 11, No. 7—(Reprint.)
Vol. 12, No. 8—(Reprint.)

List of Available Publications, February, 1926

Report

1925—Forty-Sixth Annual Report of the New Jersey State Agricultural Experiment Station and Thirty-Eighth Annual Report of the New Jersey Agricultural College Experiment Station.

Extension News Service

Through the weekly news service, 208 articles from the different departments were distributed to the farm press, the press of the state and the nearby metropolitan dailies.

Journal Series

246 S. A. Waksman. What is Humus? *Proceedings of the National Academy of Sciences,* August, 1925.
247 S. A. Waksman. The Soil Population. *Proceedings of the National Academy of Sciences,* August, 1925.
248 J. S. Joffe and H. C. McLean. Suction Force of Soils: A Note on the Application of this Principle in the Study of the Soil Plant System. *Science,* December 11, 1925.
249 H. Heukelekian and Selman A. Waksman. Carbon and Nitrogen Transformations in the Decomposition of Cellulose by Filamentous Fungi. *Journal of Biological Chemistry,* November, 1925.
250 S. A. Waksman and C. E. Skinner. The Microorganisms Concerned in the Decomposition of Cellulose in the Soil. *Journal of Bacteriology.*
251 Willem Rudolfs, H. Heukelekian and P. J. Alwin Zeller. The Relation Between Ripe Sludge and Incoming Fresh Solids. *Public Works,* April, 1926.
252 Jacob G. Lipman. The Mosquito in its Relation to Agricultural Progress. *Proceedings of the Twelfth Annual Meeting of the New Jersey Mosquito Extermination Association,* February 5-7, 1925.
253 A. L. Prince and H. W. Winsor. The Availability of Nitrogen in Garbage Tankage and in Urea in Comparison with Standard Materials. *Soil Science,* January, 1926.
254 J. G. Lipman. 3. The Fixation of Nitrogen Under Field Conditions. *Journal of the American Society of Agronomy,* August, 1925.
255 J. G. Lipman. Organic Evolution from the Point of View of the Soil Investigator. *Scientific Monthly,* September, 1925.
256 F. R. Beaudette and P. R. Edwards. The Etiology of a Canary Bird Epizootic. *Journal of Bacteriology.*
257 George W. Musgrave. Correlation of Yield of Straw and Grain in Oats in New Jersey. *Journal of the American Society of Agronomy,* December, 1925.
258 J. S. Joffe and H. C. McLean. Colloidal Behavior of Soils and Soil Fertility: II. The Soil Complex Capable of Base Exchange and Soil Acidity. *Soil Science,* March, 1926.
259 S. A. Waksman and Cornelia Carey. On the Use of the Silica Gel Plate for Demonstrating the Presence and Abundance of Cellulose-Decomposing Bacteria. *Journal of Bacteriology.*
260 Selman A. Waksman. The Micro-Biological Complexes of the Soil and Soil Deterioration. *Journal of the American Society of Agronomy,* February, 1926.
261 George W. Musgrave. A Further Note on Competition in Potatoes. *Journal of the American Society of Agronomy,* February, 1926.
262 F. R. Beaudette. B. Aertrycke Infection in Canary Birds and Parrots. *American Veterinary Medical Association,* February, 1926.
263 F. R. Beaudette. B. Aertrycke as the Etiological Agent in a Disease Affecting Squabs. *American Veterinary Medical Association,* February, 1926.

264 Thomas J. Headlee and Carl Ilg. Some Facts Relative to the Raspberry Crown Borer. *Journal of Economic Entomology,* June, 1926.

265 W. H. Martin and W. M. Peacock. Northern vs. Southern Grown Seed. *Proceedings of the Potato Association of America,* 1925, p. 23-32.

266 W. H. Martin. Disinfecting Seed Potatoes by the Dry Method. *Proceedings of the Potato Association of America,* 1925, p. 99-109.

267 Byrley F. Driggers. The Blueberry Tip Worm (*Contarinia Vacinii Felt*), A New Species of Midge Attacking Cultivated Blueberries. *Journal of the New York Entomological Society,* March, 1926.

268 S. Lomanitz. A Study of Physiological Balance for Alfalfa in Solution Cultures. *Soil Science.*

269 J. G. Lipman. The Relationship Between Economic and Biological Research in the Experiment Station. *Journal of Farm Economics,* January, 1926.

270 M. A. Blake. The Growth of the Fruit of the Elberta Peach From Blossom Bud to Maturity. *Proceedings of American Society for Horticultural Science,* 1925.

271 J. H. Clark. Some Effects of Pruning on Grape Production. *Proceedings of American Society for Horticultural Science,* 1925.

272 C. S. Beckwith. Report of the Cranberry Substation. *Proceedings of American Cranberry Growers' Association,* 1926.

273 J. M. Ginsburg and J. W. Shive. Relation Between Calcium, Nitrogen, and Protein Metabolism in the Soybean Plant. *Soil Science.*

274 J. S. Joffe. Soil Chemistry in Relation to Subsoil Drainage. *Special Publication, College of Engineering, Rutgers University.*

275 S. A. Waksman and R. J. Bubos. Microbiological Analysis of Soils as an Index of Soil Fertility: X The Catalytic Power of the Soil. *Soil Science.*

276 S. A. Waksman. Origin and Nature of Soil Organic Matter or Soil Humus: I. Introductory and Historical. *Soil Science.*

277 S. A. Waksman. Origin and Nature of Soil Organic Matter or Soil Humus: II. Method of Determining Humus in the Soil. *Soil Science.*

278 S. A. Waksman. Origin and Nature of Soil Organic Matter or Soil Humus: III. Nature of Substances Contributing to Formation of Humus. *Soil Science.*

279 S. A. Waksman and F. G. Tenny. Origin and Nature of Soil Organic Matter or Soil Humus: IV. Decomposition of Various Ingredients of Straw and Alfalfa Meal by Mixed and Pure Cultures of Microorganisms. *Soil Science.*

280 S. A. Waksman. Origin and Nature of Soil Organic Matter or Soil Humus: V. Role of Microorganisms in Formation of Humus in Soil. *Soil Science.*

281 Ray Hutson. An Non-inflammable Fumigant for Use Against Waxmoth. *American Bee Journal.* June, 1926.

282 Ray Hutson. Tongue Length and Honey Storing Ability. *American Bee Journal.*

283 W. Rudolfs. Studies on the Chemical Changes During the Life Cycle of the Tent Caterpillar. I. Moisture and fat. *Journal of New York Entomological Society.*

284 W. Rudolfs. Studies on the Chemical Changes During the Life of the Tent Caterpillar. II. Nitrogen and Its Relation to Moisture and Fat. *Journal of New York Entomological Society.*

285 George W. Martin. Utilization of Food by Young Oysters. *Journal of Agricultural Research.*

286 A. L. Prince. Report on Nitrogen. *Association of Official Agricultural Chemists,* 1925.

287 Willem Rudolfs et al. Optimum Reaction for Sluge Digestion. *Engineering News Record.*

288 Willem Rudolfs. Investigation of Mosquito Problems, Carried on at the New Jersey Agricultural Experiment Station During the Past Year. *Proceedings of the New Jersey Mosquito Extermination Association.*

289 Jacob G. Lipman. Looking Backward and Forward in Mosquito Control. *Proceedings of the New Jersey Mosquito Extermination Association.*

290 Willem Rudolfs and A. J. Fischer. Biochemical Oxygen Demand of Fresh Solids in the Course of Digestion and of Ripe Sludge. *Public Works,* June, 1926.

291 J. M. Ginsburg. Effect of Moisture, Temperature and Light on the Decomposition of Lead Arsenate in Sulfur-Lime Dry-Mix Spray. *Journal of Economic Entomology.*

292 J. S. Joffe and H. C. McLean. Colloidal Behavior of Soils and Soil Fertility: III. Cation Replacement and Saturation of Soil with Calcium. *Soil Science.*

293 S. A. Waksman. Cellulose and Its Decomposition in the Soil by Microorganisms. *Proceedings of the International Soil Science Society.*

294 H. B. Sprague. Correlations and Yield in Bread Wheat. *Journal American Society of Agronomy.*

295 J. G. Lipman, A. W. Blair and A. L. Prince The Effect of Lime and Fertilizers on the Potash Content of Soil and Crop. *Proceedings of the International Society of Soil Science.*

Semi-Technical and Popular Papers

A. W. BLAIR

Notes on Tomato Fertilizers. *Armour's Farmers' Almanac,* 1926.
Alfalfa with Wheat. *Pennsylvania Farmer,* May 1, 1926.
Using Land Plaster. *Pennsylvania Farmer,* May 8, 1926.
Chicken Manure on Corn. *Pennsylvania Farmer,* May 15, 1926.
Permanent Pasture. *Pennsylvania Farmer,* May 22, 1926.
Will Grow Potatoes. *Pennsylvania Farmer,* May 29, 1926.
Soybeans. *Pennsylvania Farmer,* June 26, 1926.

M. A. BLAKE

Apple Pollination Problem Should Not be Judged Hastily. *New Jersey State Horticultural Society News,* November, 1925.
Features of Fruit Growing May be Standardized Too Much. *New Jersey State Horticultural Society News,* November, 1925.
Thousands of Acres Still Available in New Jersey. *New Jersey State Horticultural Society News,* November, 1925.
Apples are Injured by Severe Drought. *New Jersey State Horticultural Society News,* November, 1925.
Wm. H. Crawford Gave Us Two Fine Peaches. *New Jersey State Horticultural News,* December, 1925.
Peach Varieties May Often Be Identified by Knowing Characters of the Flowers. *New Jersey State Horticultural Society News,* December, 1925.
Nursery Row Identification of Peaches is Difficult. *New Jersey State Horticultural Society News,* February, 1926.
Blooming is Not Hastened by Early Tillage of Soil. *New Jersey State Horticultural Society News,* February, 1926.
Stayman Apple Must be Kept Growing Well to do Best. *New Jersey State Horticultural Society News,* February, 1926.
Do You Know How Fast Peach Trees Should Grow in Early June? *New Jersey State Horticultural Society News,* May, 1926.
What are Right Dimensions for Georgia Peach Crates. *New Jersey State Horticultural Society News,* May, 1926.

HERMINIE R. BROEDEL

Grow Arbutus in Your Own Garden. *Gardeners' Chronicle,* May, 1926.
Chicks in Glass Houses Will Never Grow Strong. *Rural New-Yorker,* May 15, 1926.

C. H. CONNORS

Staking Dahlias. *New Jersey Dahlia News,* January, 1926.
Tuber Production in the Dahlia. *New Jersey Dahlia News,* January, 1926.
Report of the Superintendent of the Trial Garden of the Dahlia Society of New Jersey. *New Jersey Dahlia News,* January, 1926.
The Show of the New England Dahlia Society. *New Jersey Dahlia News,* January, 1926.
Selecting Dahlia Seedlings. *New Jersey Dahlia News,* April, 1926.
"Runting" of Dahlias. *New Jersey Dahlia News,* April, 1926.

ROGER W. DEBAUN

Circumventing Stem Rot. *Country Gentleman,* May, 1926.
Fertilizing Sweet Potatoes. *Country Gentleman,* May, 1926.

ARTHUR J. FARLEY

Promising New Varieties of Fruit. *Rural New-Yorker,* February, 1926.
Report of New Varieties of Fruit. *Proceedings of the N. J. State Horticultural Society,* 1925.
Spray Injury. *Proceedings of the Maryland Horticultural Society,* 1926.

E. R. GROSS

Garden Tractor Demonstration in New Jersey Agricultural Experiment Station. *Market Growers' Journal, June* 22, 1926.

RAY HUTSON

The Year's Work in Bee Husbandry at the Experiment Station. *Proceedings of the New Jersey Beekeepers' Association,* 1925.

THOMAS J. HEADLEE

The Japanese Beetle in Relation to the State of Delaware. *Transactions of the Peninsula Horticultural Society,* 1925, p. 56-58.
The Codling Moth Situation in New Jersey. *Proceedings of the N. J. State Horticultural Society,* 1925, p. 97-102.
Substantial Accomplishment in New Jersey Mosquito Control. *Proceedings of the Thirteenth Annual Meeting, New Jersey Mosquito Extermination Association,* 1926, p. 20-26. (Reprinted as Station Bulletin 437.)

JACOB S. JOFFE

Regular (almost weekly) contributions under a title "Popular Science Talks" in the *Jewish American,* a New York City weekly published in Yiddish.
Contributions dealing chiefly with scientific events, with special reference to agriculture, to the *Jewish Morning Journal,* New York City.

D. B. LUCAS

Garden Tractors. *Market Growers' Journal,* April 27, 1926.

JACOB G. LIPMAN

What New Forms of Fertilizer are Manufacturers Likely to Put on the Market by Taking Nitrogen from the Air? *Pennsylvania Farmer,* November 7, 1925.
How Does Sulphate of Ammonia Compare with Nitrate of Soda as a Top Dressing? *Pennsylvania Farmer,* November 21, 1925.
To What Extent is Chlorine Objectionable in Fertilizers? *Pennsylvania Farmer,* November 28, 1925.
Will Government or Private Operation of Muscle Shoals Reduce the Price of Fertilizers? *Pennsylvania Farmer,* December 5, 1925.
How Does Ground Oyster Shell Compare with Hydrated Lime? *Pennsylvania Farmer,* December 12, 1925.
Does Manure Lose Much of its Value if Broadcast During the Fall and Winter Months? *Pennsylvania Farmer,* December 26, 1925.
Is It Necessary to Use Lime on Land That is Producing Good Crops of Clover? *Pennsylvania Farmer,* January 9, 1926.
Is It Necessary to Replace in Fertilizers All of the Plant-food Removed by the Crops? *Pennsylvania Farmer,* January 16, 1926.

Are We Using Too Much Phosphoric Acid in Our Fertilizers? *Pennsylvania Farmer,* January 23, 1926.

What Advantage Would a Farmer Gain in Having His Soil Analyzed? *Pennsylvania Farmer,* February 6, 1926.

How is Commercial Fertilizer Used in Europe? *Pennsylvania Farmer,* February 13, 1926.

What Progress is Being Made in the Use of Concentrated Fertilizers? *Pennsylvania Farmer,* February 20, 1926.

Fertilizer Prospects for 1926. The Use of Concentrated Material in Potato Fertilizer. *Proceedings of the New Jersey Potato Association,* January, 1926.

Significance of the International Study of Soils. *Better Crops,* October, 1925.

Soil Life. Chapter in "Chemistry in Agriculture," published by The Chemical Foundation. Edited by Dr. Joseph S. Chamberlain, 1926.

W. H. MARTIN

Apple Scab Studies in 1925. *Proceedings of the N. J. State Horticultural Society,* 1925.

Results of Potato Investigations in 1925. *N. J. State Department of Agriculture,* Bul. 47.

Report of the Seed Potato Certification Committee. *Proceedings, Twelfth Annual Meeting, Potato Association of America,* 1925, p. 147-157.

Early Cutting Reduces Vigor of Seed. *Michigan Potato Growers' Exchange,* Vol. 6, No. 7.

Potato Spraying in 1925. *Hints to Potato Growers,* Vol. 6, No. 5.

Potatoes. *Armour Fertilizer Co. Almanac,* 1926.

Seed Source and Variety Test Plots in 1925. *Hints to Potato Growers,* Vol. 6, No. 6.

Certified Seed Test. *Hints to Potato Growers,* Vol. 6, No. 4.

Changes in the Potato Industry Since 1922. *Hints to Potato Growers,* Vol. 6, No. 1.

Potato Experiments in 1926. *Hints to Potato Growers,* Vol. 6, No. 12.

Changes in the Certification Rules for 1926. *Hints to Potato Growers,* Vol. 7, No. 2.

Tests With Concentrated Fertilizers in 1925. *Hints to Potato Growers,* Vol. 6, No. 7.

T. C. NELSON

New Jersey Hall and its Biologists. *Rutgers Alumni Monthly,* October, 1925.

LOUIS A. STEARNS

Codling Moth Investigations in Virginia (in conjunction with W. S. Hough, C. R. Willey and L. R. Cagle). *Va. Agr. Exp. Sta. Bul.* 248, April, 1926, p. 1-28.

ALLEN G. WALLER

Comparative Costs of Producing Eggs Throughout the United States. *Yearbook of the New Jersey State Poultry Association,* 1925.

Potato Farms in New Jersey. *Hints to Potato Growers,* February, 1926.

CARL R. WOODWARD

The Run-Down Apple Orchard. *Pennsylvania Farmer,* February 27, 1926

Top-Dressing Pays Good Returns. *Pennsylvania Farmer,* March 27, 1926.

Artificially Heated Hotbeds. *Farm Journal,* February, 1926.

Potatoes Need Nitrogen—How Much? *American Agriculturist,* February 20, 1926.

Why We Eat More Cranberries. *American Fruit Grower Magazine,* November, 1925.

Can Fertilizers and Cover Crops Replace Manure on Truck Farms? *Market Growers' Journal,* September 1, 1925.

Nitrogen Needs of Apples. *Country Gentleman,* December, 1925.

Some Glimpses of the History of Agricultural Publications. *A C E,* November, 1925.

Nitrogen Improves Yield and Quality of Raspberries. *American Agriculturist,* February 13, 1926.

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927

AGRICULTURAL BIOCHEMISTRY

Number	*Subject*	*Leader*	*Associates*
AB 1	The influence of soil composition and treatment on the vitamin content of food plants.	W. C. Russell	
AB 2	The influence of soil composition and treatment on the ash content of food plants.	W. C. Russell	

AGRICULTURAL ECONOMICS

Number	*Subject*	*Leader*	*Associates*
AE 1	Cost of production of farm products	Allen G. Waller	
AE 4	Methods of maintaining soil fertility	Allen G. Waller	
AE 5	Economic study of the poultry industry	Henry Keller	
AE 6	Economic study of the peach industry	Allen G. Waller	
AE 7	Economic study of the apple industry	Allen G. Waller	
AE 8	The rye marketing system of Central Jersey	Allen G. Waller	
AE 9	Agricultural production and marketing in Atlantic County	H. J. Baker A. E. Eldred	W. C. Funk A. G. Waller Henry Keller
AE 10	Study of Monmouth and Sussex County agriculture	Allen G. Waller	
AE 11	Study of corporation farming	Henry Keller	
AE 12	Trends in type of farming areas as indicated by farm management and organization studies	Allen G. Waller	
AE 13	History of Agriculture in New Jersey; Educational and Social Developments Prior to 1880	C. R. Woodward (Thesis)	
AE 14	History of Agriculture of New Jersey; Economic Influences and Developments	Henry Keller (Thesis)	
AE 15	An economic study of the agricultural credit situation in New Jersey	Henry Keller	
AE 16	A study of rural life worth imitating	Henry Keller	
AE 17	Metropolitan New York demand for peaches	Allen G. Waller	

AGRONOMY AND SOILS

Number	*Subject*	*Leader*	*Associates*
A 2	Altalfa strains	G. W. Musgrave	
A 3	Studies in competition and size of potato seed piece	G. W. Musgrave	
A 4	Corn breeding by inbreeding and selection in self-fertilized lines	G. W. Musgrave	H. B. Sprague
A 6	Potato variety test	G. W. Musgrave	
A 8	Tests of species and varieties of field crops	G. W. Musgrave	
A 9	Improvements of potato seed	G. W. Musgrave	
A 10	Amount and rate of growth in certain field crops	G. W. Musgrave	
A 11	Ecologic and economic study of New Jersey Pastures	G. W. Musgrave	
A 12	Factors influencing the propagation and growth of selected strains of creeping bent grasses	G. W. Musgrave	

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927—Cont.

Soil Chemistry and Bacteriology

Number	*Subject*	*Leader*	*Associates*
S. C. & B. 3	Sulfur oxidation	J. G. Lipman	A. W. Blair A. L. Prince J. Joffe S. A. Waksman
S. C. & B. 5	Fertilizer ratio experiments	A. W. Blair	W. H. Martin
S. C. & B. 7	Fertilizer ratio experiments	A. W. Blair	W. H. Martin
S. C. & B. 11	Weed plots, or the influence of fertilizers upon natural vegetation	J. G. Lipman	A. W. Blair A. L. Prince
S. C. & B. 12	Utilization of plant food nitrogen in the presence of phosphoric acid and potash	A. W. Blair J. G. Lipman	H. C. McLean A. L. Prince
S. C. & B. 14	Soil actinomyces	S. A. Waksman	Clara Wark J. Joffe
S. C. & B. 18	Lime to improve the crop-producing power of acid soils	A. W. Blair	
S. C. & B. 19	The relation of sulfur, sulfur phosphate mixtures, fertilizers, manure, lime and varieties to yield and disease control of sweet potatoes	R. F. Poole H. C. McLean	
S. C. & B. 20	Methods of applying fertilizers to potatoes	J. G. Lipman A. W. Blair	
S. C. & B. 21	An inventory of the non-spore, punctiform colony forming bacteria in the soil	H. J. Conn J. S. Joffe	
S. C. & B. 22	Nitrogen availability	A. W. Blair	A. L. Prince
S. C. & B. 23	Fertilizer comparison	A. W. Blair	
S. C. & B. 24	The effect of heavy applications of dry organic matter on the germination and growth of legume and non-legume crops	A. W. Blair	H. C. McLean A. L. Prince H. W. Winsor
S. C. & B. 25	Critical study of soil microbiological methods and the principles upon which the are based		
S. C. & B. 26	On the mechanism of decomposition of organic matter in the soil and the processes contributing to the formation of soil humus		
S. C. & B. 27	Colloidal behavior of soil and soil fertility		
S. C. & B. 28	Base exchange in soils		
S. C. & B. 29	A study of the effect of concentrated fertilizers in germination and growth		
S. C. & B. 30	The inoculating value of small quantities of manure in the growing of legume and non-legume green manure crops		
S. C. & B. 31	The continuous growing of wheat and rye with and without a legume cover crop.		
S. C. & B. 32	The influence of legumes as compared with non-legumes in maintaining soil-fertility.		
S. C. & B. 33	The effect of varying amounts of phosphoric acid (nitrogen and potash remaining constant) on potatoes		
S. C. & B. 34	Soil improvement by a 5 year rotation and by growing sweet clover as a self-seeding crop		
S. C. & B. 35	A study of the causes of the toxicity of ammonium sulfate and other ammonium compounds	A. L. Prince A. W. Blair	R. A. Diehm
S. C. & B. 36	Studies on the relation of soil type and soil treatment on pasture vegetation	L. L. Lee	H. W. Reuszer
S. C. & B. 37	The availability of nitrogen in nitrate of soda, ammonium sulfate and dried blood when the proportion of phosphoric acid and potash are varied	J. G. Lipman	A. W. Blair A. L. Prince

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927—Cont.

PLANT PATHOLOGY

Number	*Subject*	*Leader*	*Associates*
P. Path. 24	Orchard disease investigations	W. H. Martin	C. M. Haenseler E. S. Clark
P. Path. 25	Cereal disease investigations	W. H. Martin	
P. Path. 26	Vegetable disease investigations	W. H. Martin	C. M. Haenseler John Small E. S. Clark C. Chupp
P. Path. 27	Small fruit disease investigations	W. H. Martin	
P. Path. 28	Field crops disease investigations	W. H. Martin	C. M. Haenseler C. Chupp
P. Path. 29	Investigations of potato problems	W. H. Martin	E. S. Clark J. A. Sutfin
P. Path. 30	Sweet potato diseases	W. H. Martin	J. A. Sutfin
P. Path. 31	Investigation of Verticillium wilts	C. M. Haenseler	
P. Path. 32	Root-rot of field peas	C. M. Haenseler	
P. Path. 33	Plant Disease Survey	W. H. Martin	Members of Dept.

PLANT PHYSIOLOGY

Number	*Subject*	*Leader*	*Associates*
P. Ph. 1	Salt requirements of representative agricultural plants	J. W. Shive	W. H. Martin
P. Ph. 5	The relative availability and efficiency of various soluble and insoluble iron compounds in relation to plant production	J. W. Shive	
P. Ph. 6	Study of ammonium sulfate in relation to plant growth	J. W. Shive	
P. Ph. 7	A study of plant growth and crop production in relation to the size and weight of seed	J. W. Shive	

DAIRY HUSBANDRY

Number	*Subject*	*Leader*	*Associates*
D. H. 1	Breeding experiments with dairy cattle	J. W. Bartlett	C. B. Bender
D. H. 2	Feeding milch cows during the dry period	J. W. Bartlett	C. B. Bender
D. H. 3	Minimum milk requirements for raising dairy calves	J. W. Bartlett	C. B. Bender
D. H. 5	Factors affecting the total butterfat content of cows' milk during a period of two days	J. W. Bartlett	C. B. Bender
D. H. 6	Rations for dairy heifers during the winter months	J. W. Bartlett	C. B. Bender
D. H. 9	The relation of the ductless glands to growth and milk production	J. W. Bartlett	C. B. Bender
D. H. 10	Studies of color pigmentation in the skin of dairy cattle	J. W. Bartlett	C. B. Bender
D. H. 11	A study of the changes that take place in the topline of dairy calves	J. W. Bartlett	C. B. Bender
D. H. 12	A study of the effect of the plane of nutrition of milch cows during the dry period upon the subsequent lactation	J. W. Bartlett	C. B. Bender

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927—Cont.

DAIRY HUSBANDRY—Continued

Number	*Subject*	*Leader*	*Associates*
D. H. 13	The effectiveness of commercial preservatives in composite samples, with special reference to bichloride of mercury	J. W. Bartlett	F. C. Button
D. H. 14	The relation of alfalfa meal as a roughage to mastitus in milking cows	J. W. Bartlett	C. B. Bender
D. H. 15	Applying the Troy-Fucoma method of testing ice cream for butterfat to the Babcock equipment	J. W. Bartlett	
D. H. 16	Normal growth of dairy heifers	J. W. Bartlett	
D. H. 17	Effect of temperature and humidity on milk production of dairy cows	J. W. Bartlett	
D. H. 18	The effect of mold growth on the butterfat test of composite samples	J. W. Bartlett	F. C. Button
D. H. 19	The effect of the hardening room on the proteins of ice cream	F. C. Button	

ENTOMOLOGY

Number	*Subject*	*Leader*	*Associates*
E 1	Mosquito control	T. J. Headlee	
E 2	Climate and insect investigations	T. J. Headlee	
E 3	Orchard insect investigations	T. J. Headlee	
E 4	Small fruit insect investigations	T. J. Headlee	
E 5	Vegetable insect investigations	T. J. Headlee	
E 6	Insects injurious to market milk	T. J. Headlee	
E 7	Arthropods injurious to poultry production	T. J. Headlee	
E 8	Stickers, spreaders and diluents for dusting and spraying mixtures	T. J. Headlee	
E 9	Cranberry problems	T. J. Headlee	C. S. Beckwith
E 11	Greenhouse insect investigations	T. J. Headlee	
E 12	Soil infesting insects	T. J. Headlee	
E 13	Investigations of dusts and stickers, spreaders and dilutents for spraying and dusting mixtures	T. J. Headlee	
Oy 1	Scientific methods of oyster culture	T. C. Nelson	

HORTICULTURE

Number	*Subject*	*Leader*	*Associates*
H 1	Plant food studies with peaches	M. A. Blake	A. J. Farley C. H. Connors
H 2	Peach pruning	M. A. Blake	C. H. Connors
H 3	Apple pruning	M. A. Blake	A. J. Farley
H 4	Peach breeding	C. H. Connors	M. A. Blake A. J. Farley
H 5	Plant food studies with apples	A. J. Farley	
H 6	Two methods of planting peach trees	A. J. Farley	

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927—Cont.

HORTICULTURE—Continued

Number	Subject	Leader	Associates
H 7	Rate of growth of fruits, apple, peach, pear	A. J. Farley	J. H. Clark
H 9	Carnation breeding	C. H. Connors	
H 10	Carnation culture	M. A. Blake	C. H. Connors
H 11	Rose culture	M. A. Blake	C. H. Connors
H 12	Plant food studies with tomatoes	L. G. Schermerhorn	
H 14	Environmental factors in hydrangea culture	C. H. Connors	M. A. Blake
H 15	Plant food studies with sweet potatoes	L. G. Schermerhorn	
H 16	Plant food studies with asparagus	L. G. Schermerhorn	
H 17	Cantaloupe studies	L. G. Schermerhorn	
H 18	Root stocks for peaches and apples	M. A. Blake	
H 19	Cultural studies with herbacious perennial plants	C. H. Connors	
H 20	Studies with miscellaneous vegetables in North Jersey	L. G. Schermerhorn	H. F. Huber
H 21	Factors influencing the size of peaches, including thinning studies	M. A. Blake	
H 22	Influence of amounts and time of application of nitrogen on yields of various vegetables	L. G. Schermerhorn	
H 23	Influence of size of root on growth and yield of asparagus	L. G. Schermerhorn	H. F. Huber
H 24	Propagation of ornamental plants	C. H. Connors	H. M. Biekart
H 25	Test and dissemination of new species, types and varieties of fruits, flowers, vegetables and ornamental plants	M. A. Blake	A. J. Farley L. G. Schermerhorn C. H. Connors
H 26	Cultural and nutritional studies with small fruits	G. T. Nightingale	
H 27	Studies of the growth responses of horticultural plants, associated chemical changes in reserve food and the utilization of nutrients	G. T. Nightingale	L. G. Schermerhorn

POULTRY HUSBANDRY

Number	Subject	Leader	Associates
P. H. 3	Improvement of poultry through the establishment and operation of egg laying and breeding contests	W. H. Allen	
P. H. 4	The improvement of poultry through the aiding of poultry exhibition in New Jersey.	W. H. Allen	
P. H. 10	Study of contagious epitheliosis	F. R. Beaudette	
P. H. 11	The diagnosis of poultry diseases occurring in New Jersey	F. R. Beaudette	
P. H. 13	The development of a high producing strain of single comb white leghorn	W. H. Allen	
P. H. 14	The analysis of individual egg production records	C. S. Platt	
P. H. 18	The effects of using artificial lighting on breeding hens	W. H. Allen	
P. H. 23	Natural poultry life span	W. H. Allen	
P. H. 24	A study of Heterakis perspiccillum on poultry	F. R. Beaudette	J. J. Black
P. H. 25	Observations on the occurrence of oocysts of Eumeria avium in the cecal contents of domestic fowls	F. R. Beaudette	
P. H. 26	Relation of soil reaction to infectious poultry disease organisms	F. R. Beaudette	
P. H. 27	The modification of existing poultry houses to provide optimum environment during winter confinement	W. H. Allen	

List of Projects of the New Jersey Agricultural Experiment Station for 1926-1927—Cont.

POULTRY HUSBANDRY—Continued

Number	*Subject*	*Leader*	*Associates*
P. H. 28	A study of avian paratyphoid organisms	F. R. Beaudette	
P. H. 29	A study of the feeding value of Protozyme, fungus enzyme, in the feeding of poultry	R. R. Hannas	M. Decker
P. H. 30	The effect of using electric lights on laying birds	W. H. Allen	R. R. Hannas
P. H. 31	A comparison of two dry mash mixtures	W. H. Allen	M. Decker R. R. Hannas
P. H. 32	A comparison of three sources of animal protein	W. H. Allen	M. Decker R. R. Hannas
P. H. 33	The effect of length of cycle and position of egg in the cycle upon hatchability	R. R. Hannas	M. Decker
P. H. 34	The effect of climatic conditions, especially sunlight, at the time the eggs are laid upon the hatchability	R. R. Hannas	M. Decker
P. H. 35	Studies of body weight and body changes resulting from egg production	W. H. Allen	C. S. Platt
P. H. 36	A study of "Watery Whites" in market eggs	W. H. Allen	C. S. Platt
P. H. 37	The normal variation in market quality of eggs from individual birds	W. H. Allen	C. S. Platt

AGRICULTURAL ENGINEERING

R. E. 1	Fertilizer distributors	E. R. Gross	D. B. Lucas
R. E. 2	Vegetable irrigation survey	E. R. Gross H. F. Huber	D. B. Lucas
R. E. 3	Rural electrification survey	E. R. Gross	
R. E. 4	Duty of vegetable and truck growing machinery	E. R. Gross	

SEED ANALYSIS

S. A. 1	Germination of beet seed	J. G. Fiske	
S. A. 2	Germination of celery seed	J. G. Fiske	
S. A. 3	Difference between mammoth red clover and common red clover	J. G. Fiske	
S. A. 4	Experiments in soil inoculation	J. G. Fiske	
S. A. 5	Longevity of grass and clover seeds	J. G. Fiske	
S. A. 6	The drying of agricultural seeds for the reduction of moisture content as a preservative measure in storage	J. G. Fiske	
S. A. 7	The best laboratory medium for germinating corn	J. G. Fiske	
S. A. 8	Disinfecting seeds	J. G. Fiske	

SEWAGE INVESTIGATION

S. I. 1	Biology of Sewage Disposal	W. Rudolfs	H. Heukelekian D. Peterson P. J. A. Zeller

STAFF CHANGES

Appointments

Clarence N. Henderson, Junior Clerk.
Carl D. Jones, Microbiologist.
Arthur L. Stahl, Laboratory Assistant.
Evangline L. Bodine, Junior Clerk-Stenographer.
Richard Huizing, Mosquito Inspector.
Harold C. Stevens, Insectary Assistant.
Richard E. Moody, Field Assistant.
Thurlow C. Nelson, Biologist and Oyster Research Specialist.
George Martin, Botanist.
Louisa M. Clickner, Junior Clerk.
Willard H. Allen, Acting Poultry Husbandman.
Conrad Wehrfritz, Janitor.
Lillian Rosson, Clerk-Stenographer.
John S. Rozanski, Poultryman's Helper.
Adella Davis, Junior Clerk-Stenographer.
Elsie Waddington, Seed Tester.
Daggmar Peterson, Research Zoologist.
Gabriel Kady, Farm Hand.
Charles Chupp, Assistant Plant Pathologist.
Gertrude A. Gleason, Junior Clerk-Stenographer.
Evelyn N. Rooney, Junior Clerk-Stenographer.
Mildred B. Murphy, Home Demonstration Agent at Large.
Leslie M. Black, Assistant Extension Specialist in Poultry Husbandry.
Walter C. Russell, Biochemist.
Alvaro B. Fagundes, Research Assistant in Soil Fertility.
Howard F. Huber, Assistant Director of Research.
Edward E. Evaul, Research Assistant in Agronomy.
Herbert W. Reuszer, Research Specialist in Agronomy.
Theodore J. Frizzell, Research Assistant.
Warren W. Wagner, Dairyman's Helper.
Sidney S. Frizzell. Dairyman's Helper.
Claude L. Frantz, Dairyman's Helper.
Fred Gauntt, Head Dairyman.
Isaac J. Paulding, Dairyman's Helper.
Dorothy Schoenbrunn, Junior Clerk-Stenographer.
Morell B. Austin, Dairyman's Helper.
Vernon L. Hurff, Dairyman's Helper.
Everett W. Hitchings, Dairyman's Helper.
Herbert J. Harriet, Dairyman's Helper.
Edgar G. Richards, Dairyman's Helper.
Lee R. Cunningham, Dairyman's Helper.
Joseph Seiler, Assistant Instructor.
Harold P. Ellison, Farm Hand.
Harold McCumsey, Farm Hand.
Arnold F. Stout, Foreman Field Crops.
John Sigle, Farm Hand.
Edward Stokes, Carpenter and Painter.
Eleanor R. Suydam, Junior Clerk-Stenographer.
Gordon T. Nightingale, Research Specialist in Horticulture.
Malcolm A. Adams, Farm Hand.
John Anderson, Farm Hand.
Russell G. Breece, Farm Hand.
Samuel Adams, Farm Hand.
James A. Beatty, Assistant Foreman, Egg Laying Contest.
Alois C. Schlott, Foreman, Egg Laying Contest.
Janet G. Banks, Home Demonstration Agent, Gloucester County
William G. Frisbie, Club Leader.

Margaret C. Shepard, Home Demonstration Agent, Essex County.
Margaret Miller, Clerk-Stenographer.
Albert S. Barnhart, County Agricultural Agent at Large.

Resignations

Frederick A. Hall, Assistant to Director.
Donald W. Baker, Head Dairyman.
Howard F. Huber, Assistant Olericulturist.
Milton R. Stalker, Clerk.
Carl D. Jones, Microbiologist.
Bonnie R. Fudge, Laboratory Assistant.
George Martin, Botanist.
George W. Hervey, Poultry Research Specialist.
Forrest H. Clickner, Assistant Poultry Specialist.
Theresa Sheehan, Junior Clerk-Stenographer.
Margaret Runyon, Clerk-Stenographer.
George Place, Poultryman's Helper.
Louisa M. Clickner, Junior Clerk.
Edith Werner, Clerk-Stenographer.
Herbert D. Trowbridge, Student Janitor.
Myrtle Cody, Clerk-Stenographer.
Arthur J. Packard, Farm Hand.
Hazel N. Rupert, Clerk-Stenographer.
Morell B. Austin, Dairyman's Helper.
Andrew MacIntyre, Dairyman's Helper.
Bernard Hale, Dairyman's Helper.
George C. Denzer, Dairyman's Helper.
Warren W. Wagner, Dairyman's Helper.
Sidney S. Frizzell, Dairyman's Helper.
Claude L. Frantz, Dairyman's Helper.
Isaac J. Paulding, Dairyman's Helper.
Vernon L. Hurff, Dairyman's Helper.
Herbert J. Harriet, Dairyman's Helper.
Joseph Seiler, Assistant Instructor.
Joseph Leppert, Farm Hand.
Samuel Johnson, Farm Hand.
Walter Jefferies, Farm Hand.
Harold P. Ellison, Farm Hand.
John Prungel, Farm Hand.
Malcolm H. Adams, Farm Hand.
Harold C. Stevens, Insectary Assistant.
Richard E. Moody, Field Assistant.
Thurlow C. Nelson, Biologist and Oyster Research Specialist.
Thomas C. Rogers, Research Assistant.
Julius Poesek, Farm Hand.
H. M. Biekart, Florist.
Robert F. Poole, Assistant Plant Pathologist.
Henry L. Macon, Instructor.
Anna G. Conlon, Clerk-Stenographer.
Edith Deere, Clerk-Stenographer.
James A. Beatty, Assistant Foreman Egg Laying Contest.
K. Evelyn Sly, Home Demonstration Agent, Essex County.

Leave of Absence

George W. Musgrave, Agronomist.

Report of the Department of Agricultural Biochemistry

WALTER C. RUSSELL

The department of agricultural biochemistry was organized in October, 1925, for the purpose of doing research work on projects in the field of human nutrition and of cooperating with other departments at the Experiment Station on problems of the nutrition of farm animals.

A laboratory was equipped and a colony of albino rats started for use in animal experimentation and in the biological analysis of foods. The breeding animals used in starting the colony were obtained from the Wistar Institute of Anatomy and Biology, Philadelphia, Pa., and are known as the Wistar Strain. A chemical laboratory was organized for control and research work on the chemical phases of agricultural biochemistry. especially in the field of nutrition.

Preliminary tests of food materials to be used in the preparation of the basal rations required for vitamin studies, were made with groups of albino rats. Research work of a fundamental nature was begun to determine the influence of the conditions of growth, particularly soil composition and treatment, on the nutritive value of various food crops, with special reference to the vitamin and ash content. An attempt will be made to correlate the data concerning the vitamin content of food plants with those on the soil composition and treatment, with the idea of learning something of the fundamental nature of vitamins. At the present time the vitamin B content of two varieties of wheat, Dawson's Golden Chaff and Red Rock, is being studied. The formal statements of the projects on which work has been started are as follows:

Project 1—The Influence of Soil Composition and Treatment on the Vitamin Content of Food Plants,

Project 2—The Influence of Soil Composition and Treatment on the Ash Content of Food Plants.

The Cel-O-Glass Fellowship was established as a temporary industrial fellowship by Cello Products, Inc., with a stipend of $1,200. Mr. O N. Massengale has accepted the appointment as fellow for the year, beginning July 1, 1926. A tentative statement of the project to be studied is (Project 3) A Study of the Influence of Ultraviolet Light on Animal and Plant Life and the Value of Cel-O-Glass as a Medium for the Passage of this Radiation.

Cooperation was given to other departments of the Experiment Station in the following joint projects:

(a) With the Department of Dairy Husbandry—
  Effects of Ultraviolet Irradiation and Green Feed on the Calcium and Phosphorous Content of the Blood and Milk of Cows on an Adequate Diet but Protected from Direct Sunlight (Dairy Project No. 23),

(b) With the Department of Animal Husbandry—
  The Effect of Feeding Nitrogenous Foods on the Nitrogen Content of the Shoulder, Side, and Ham of the Hog.

Report of the Department of Agricultural Economics

ALLEN G. WALLER

The writer returned to the Experiment Station on July 1, 1925, to take charge of the research work in the department of agricultural economics under a cooperative agreement with the Bureau of Agricultural Economics, United States Department of Agriculture. The work for the year has been to organize research for the development of a sound and active agricultural program. This has meant the establishment of commodity and subject matter committees appointed by the chairman of the Steering Committee, Director H. J. Baker. The Steering Committee is composed of Director Baker, Director Lipman; W. B. Duryee, Secretary of Agriculture, and Allen G. Waller, as secretary. The cooperating agencies are the Agricultural Experiment Station, College of Agriculture, Extension Division, State Department of Agriculture, United States Department of Agriculture, and the State Federation of County Boards of Agriculture.

The commodity and subject matter committees appointed were as follows:

Animal Husbandry Committee	Chairman F. G. Helyar
Crops Committee	Chairman G. W. Musgrave
Dairy Committee	Chairman J. W. Bartlett
Land Utilization Committee	Chairman A. W. Blair
Marketing and Transportation Committee	Chairman Henry Keller, Jr.
Poultry Committee	Chairman W. H. Allen
Fruit Committee	Chairman M. A. Blake
Vegetable Committee	Chairman L. G. Schermerhorn
White Potato Committee	Chairman W. H. Martin
Statistician to all committees	H. B. Weiss
Secretary to all committees	Allen G. Waller

The chairmen of these committees have associated with them certain designated members of the staff from the Experiment Station, the State Department of Agriculture, and the Extension Division of the College of Agriculture. These committees all met during the month of September, 1925, and agreed on the information that should be obtained in order to make up a sound agricultural program for the state. They have already obtained a considerable amount of the data necessary.

To date the following farm management records have been taken:

	farms
Poultry records	120
Gloucester County truck records	50
Cumberland and Salem County dairy records	40
Burlington County dairy records	48
Mercer County general records	29
Sussex County dairy records	31
Monmouth County potato records	48
Monmouth County dairy, truck and general records	35
Miscellaneous	3
Total	404

These records have not been completely tabulated, but preliminary reports have been made on the potato and poultry farm records. Most of these surveys have been made in areas that were surveyed about ten years ago and the changes in farm business on the same farms are being analyzed.

The preliminary reports on poultry and potato farms follow:

POTATO FARMS IN NEW JERSEY

During the past five years, the potato acreage in the state has been reduced about one-third. This reduction has been due to lower profits and even losses which were resulting from the increased competition on our markets, from growing the crop where conditions were not suitable, from growing the wrong variety, from lack of grading standards, and from other factors. These points were all brought out in the joint report made three years ago by the State Federation of County Boards, the College of Agriculture, and the Experiment Station, and the State Department of Agriculture. The conditions facing the potato growers were clearly stated at that time, and developments since then have proved their correctness.

Practical Value of Economic Information

That report was a fine example of economic information presented to an agricultural industry that could be used as a guide for individual action. The nearly complete change in variety grown, the reduction in acreage, the steps toward a better standardized product, the increased use of certified seed, and the adoption of spraying in certain communities have all had a part in the adjustment of New Jersey's potato areas, in the effort to place the potato business on a profitable basis once more.

In 1915, when the potato industry was booming and the acreage was still on the increase, farm business records were obtained from 370 farms in Central Jersey. Last year records were obtained from 48 of the more successful farms studied in 1915. Table 1 shows what these 48 farms did in 1924 as compared with 1914. These records show what changes have taken place on these particular farms in the last ten years to meet the changing economic conditions.

They also present a comparison of expenses and income for the two years.

Increased Acreage of Truck Crops

In 1924, ten of the 48 farms had a larger farm income than 1914, but the average of the 48 was about 45 per cent less than the average of ten years ago. It should be stated, however, that the price of potatoes on the New York market in 1924 was the lowest since 1915. The average acreage of individual crops per farm had not changed materially, with the exception that truck crops had increased from 1.1 acres to 6 acres as an average. The average acreage of potatoes per farm had only slightly decreased—from 33.4 acres in 1914 to 29 in 1924—while the corn and winter grain acreage was practically the same. Hay was slightly decreased and fruit showed a slight increase.

Expenses Nearly Double

Total expenses per farm had increased 73 per cent, the largest amount of this increase being represented by a labor cost which had nearly doubled; the price of seed potatoes increased 53 per cent; other seed, 106 per cent; fertilizer, 22 per cent; taxes, 188 per cent; miscellaneous expenses, 120 per cent. Livestock receipts had increased 86 per cent, although the number of cows had decreased slightly; the number of sows decreased 48 per cent; while poultry increased 10 per cent.

Kinds of Changes

Averages, of course, do not tell the whole story, because of the difference in amount of change in the individual farms. For instance, on nine of the ten farms that had larger incomes in 1924 than 1914, the principal crop and livestock organization changes were as follows:

Farm 1. Slightly greater acreage of potatoes in 1924, other crops and livestock about the same.
Farm 2. Heavy increase in truck crops, 50 per cent cut in potatoes, livestock about the same.
Farm 3. Increase in truck crops, potatoes about the same, increase in poultry.
Farm 4. Increase in potato and apple acreage, livestock the same, roadside market.
Farm 5. Large increase in fruit and drop in potatoes.
Farm 6. Large increase in livestock and 33 acres of potatoes reduced to 21.
Farm 7. Large fruit increase.
Farm 8. About the same acreage of the different crops, greater livestock receipts and evidently greater care in expenditures as labor costs were not proportionately greater, and feed costs were less.
Farm 9. Nineteen acres of truck crops taking place of hay and rye.

In some cases, no doubt, labor efficiency has increased, and there are many other factors that should be considered. It will be seen that these farms have made various kinds of adjustments in the efforts to meet changing conditions. The tendency toward truck crops will probably increase. As shown in table 1, the average acreage of truck crops has increased considerably, and this tendency will probably continue. It should also be noted that in 1914 only 12 of these farms were growing any truck crops for sale; whereas in 1924, 25 of them were in the truck business, with 1 farm having as high as 63 per cent of its acreage in truck crops.

TABLE 1

Comparison of Business on 48 *Farms in Central Jersey for the Years* 1914 *and* 1924

CROPS	AVERAGE CROP ACRES PER FARM		AVERAGE RECEIPTS PER FARM	
	1914	1924	1914	1924
Corn	13.9	13.3	$130.27	$169.38
Potatoes	33.4	29.1	4,134.13	3,274.50
Winter Grain	12.9	13.0	269.91	365.35
Hay	20.1	16.0	285.25	260.27
Truck Crops	1.1	6.1	58.96	602.77
Tree Fruits	4.2	5.7	150.40	687.84
Miscellaneous Crops	1.0	.3	24.50	33.77
Average Crop Acres per Farm	86.6	83.5		
Average Receipts per Farm			$5,053.42	$5,393.88
Average Livestock Receipts			599.90	1,116.48
Average Miscellaneous Receipts			43.91	40.64
Average Total Receipts per Farm			$5,697.23	$6,551.00

EXPENSES	AVERAGE PER FARM	
	1914	1924
Labor	$970.79	$1,766.23
Repairs, Building and Machinery	126.42	195.98
Feed	99.25	269.33
Horseshoeing	28.31	19.75
Seed Potatoes	353.73	539.85
Other Seed	131.81	271.29
Fertilizer	862.46	1,056.21
Fuel and Oil	2.42	95.29
Insurance	39.08	88.44
Taxes	131.56	377.73
Other Expenses	158.06	349.25
Average Total Expenses per Farm	$2,903.89	$5,029.35
Average Farm Income per Farm	$2,793.34	$1,521.65

Nine Successive Years on One Farm

Records available from one successful potato farm for nine consecutive years, 1916 to 1924, inclusive, show that 76 per cent of its total net farm income and 90 per cent of the total labor income for the 9-year period, was obtained in the first five years, 1916 to 1920, inclusive. In other words, this particular farmer during the 4-year period, 1921 to 1924, inclusive, received for his own labor, less than the going wages of the hired man. This farm increased its potato acreage more than double from 1916 to 1920, and since has gradually decreased to approximately a 60 per cent larger acreage than in 1916. Its income was lowest in 1922; it has since gradually increased, but has not yet reached that of earlier years.

A study is now being made of the different farming sections in New Jersey to determine the most profitable farm organization of crops and livestock for any particular section. This study, which will also include markets, competition, varieties, and methods of production, ought to be the basis for a sound agricultural program for New Jersey.

POULTRY FARMS IN NEW JERSEY

The poultry industry in New Jersey has been growing steadily in recent years. Location, market, climate, and soil all play a part in this development. Large centers specializing in egg production have developed around the Vineland, Hammonton, Dorothy, Tom's River and Lakewood sections, and specialized poultry plants may be found in practically every county of the state. The capon industry also seems to be growing with probably its largest development in Burlington County, where it is a profitable sideline on a large number of dairy and general farms. Farm flocks have taken a definite place in the business of many farms in the general farming and dairy sections of the state.

The 1920 census showed that the state had 2,534,371 birds, and of these about one-fourth were in Hunterdon and Cumberland counties. The preliminary 1925 census reports that on January 1, 1925, New Jersey farms had over four million birds (4,113,622), or an increase of 62 per cent, and the number of eggs produced had more than doubled in the same reports.

In 1921 the State Department of Agriculture estimated that from one-fifth to one-sixth of the poultry in this state was on commercial poultry farms. During this past winter, a farm business record was obtained from 120 commercial poultry plants and the following paragraphs are a preliminary report of these records. These farms were well distributed about the state and give a cross-section of the business, covering the year November 1, 1924, to November 1, 1925.

Farm Income, Labor Income, and Capital

The average net farm income was $2,057, and this, after allowing 5 per cent on investment, which averaged $14,477, left $1,333 for the operator's work, or labor income. Nine years ago a similar survey of 150 poultry farms showed an average net farm income of $1,092, and an average investment of $7,243, with a labor income of $730. Compared to the poultry year 1915-16, the average amount of capital necessary on the poultry farms has doubled and the farm income and labor income have not quite doubled, but nearly so. Apparently, the poultry farms of New Jersey have fully held their own with other types of farming.

Size of Flocks

The flocks of these 120 farms averaged larger than those of the 150 farms nine years ago. On November 1, 1924, the average flock was 379 hens and 657 pullets, or a total of 1,036 birds. In the old survey the average was 737 birds. The labor income per bird in 1915-16 was about $1, whereas last year it was a trifle over $1.25. These 120 farms are carrying this year an average flock of 1,229, or an increase of over 18 per cent.

Production per Bird

Good egg production is essential for profits. The average production per bird (November, 1924, to November, 1925) was 113 eggs, and in the previous survey it was 109. This is figured on the number of birds in the flock at the beginning of the poultry year, November 1. Four farms with an egg production of less than 60 got no labor income. Of thirteen farms with a production of 60 to 80 eggs, only three received any labor income. In other words, one-seventh of the flocks had an average production of less than 80 eggs per bird, and only three of these flocks gave their owner any pay for his year's work.

Prices

The average price received for eggs was $0.478 per dozen, making egg sales per hen amount to $4.50. This compares with the average price of $0.34 per dozen and egg sales of $2.90 per hen nine years ago. Egg sales on these 120 farms were 75.6 per cent of all farm receipts.

Sales of broilers and fowls averaged $785 per farm, or over 12 per cent of all receipts. Sales of baby chicks and pullets accounted for about 5 per cent of all receipts. Twenty-seven farms were selling some baby chicks and 14 were selling pullets. On the other hand, 48 farms, or 2 out of every 5, were purchasing some baby chicks, and 7 farms were buying some pullets.

Lights

Over 80 per cent, or 98 of the 120 commercial plants were using artificial lights; 62 were using them in the morning, 23 in the evening, and 13 both morning and evening.

Size of Farm

The average size of the farms was 24.5 acres, with 7.5 acres in crops. This is somewhat larger than the farms of nine years ago that averaged 11.6 acres per farm and 4.6 acres in crops. The commercial poultry farms in New Jersey are essentially one-man owned and operated farms. The average cost of hired labor on the 120 farms was $435. Of the 120 farms, however, only 69 hired any labor, and of these 69, 47 were hiring labor regularly, while 22 employed extra labor only at certain times of the year.

Heavy Production Pays

A glance at the following data shows that farms averaging over 140 eggs a year are most likely to succeed:

Less than 60,	4 farms	No plus labor income.
61 to 80,	13 farms	Only 3 plus labor incomes.
81 to 100,	22 farms	16 plus labor incomes.
101 to 120,	36 farms	32 plus labor incomes.
121 to 140,	26 farms	24 plus labor incomes.
Over 140,	19 farms	18 plus labor incomes.

ALFALFA WORK

During August, 1925, a trip was made to Chicago and Wisconsin with H. W. Jeffers from the Walker-Gordon Farms, to investigate the possibilities of artificially curing alfalfa and forage. Information was obtained and data were assembled for a report, which was presented at a committee meeting at Philadelphia in January, 1926. Some time during June was spent in investigating large tracts of land suitable for the economical production of alfalfa. Arrangements are being made for a detailed study of the alfalfa drying plant now in course of construction on the Walker-Gordon Farms at Plainsboro. This study will include all costs, the value of the artificially cured alfalfa from the nutrition standpoint, and the possibilities of such an innovation as an economic part of our agriculture.

CALF RAISING

During the winter of 1925 and 1926 a committee was appointed to study the practicability of raising calves in New Jersey for replacements in our dairy herds instead of purchasing large numbers of animals from other states. This committee was composed of members representing the Experiment Station (department of agricultural economics and dairy husbandry), the Extension Division of the College of Agriculture, and individual dairymen. Meetings were held at New Brunswick, Plainsboro, Somerville, and New York City. Considerable data were gathered and the project may be tried this coming year.

TRANSPORTATION SURVEY

Transportation surveys, as a part of the necessary information for our agricultural program, were made by the State Department of Agriculture under Mr. Weiss' direction. These surveys included Burlington County, Hammonton area in Atlantic County, Gloucester County, and Monmouth County. They show the growing importance of the truck as a means of transporting farm products in New Jersey and some of the effects on the farm organization on the individual farms. The details of these studies will be printed from the State Department of Agriculture.

PEACH STUDY

A bulletin[1], covering costs of producing peaches in New Jersey and some facts on the marketing of the crop, is now ready for the printer.

COST OF PRODUCING CANHOUSE TOMATOES

At the request of the New Jersey State Federation of County Boards of Agriculture, information was furnished on the cost of producing canhouse tomatoes. The figures in bulletin 353 were brought up to date, and table 2 gives a summary for the years 1914- to 1925, inclusive:

TABLE 2

Cost of Producing Can-House Tomatoes in New Jersey

YEAR	COST PER ACRE	YIELD PER ACRE	COST PER TON
		tons	
1914	$61.11	4.85	$12.60
1918	133.56	6.37	20.96
1919	118.41	2.09	56.56
1920	135.62	6.07	22.34
Avg. (1918, 1919, 1920)	124.06	4.85	25.58
1921	105.45	4.85	21.74
1924	119.53	5.00	23.91
1925	131.69	7.00	18.81

COST OF PRODUCING EGGS

At the request of the State Poultry Association, figures were assembled on poultry costs form different sections of the country and presented at the State Poultry Convention in Atlantic City, October 9, 1925. The material was all printed in the 1925 Yearbook and report of the annual convention of the New Jersey State Poultry Association.

MONTHLY ECONOMIC REVIEW OF NEW JERSEY AGRICULTURE

On the fifteenth of each month the department issues a summary of the economic conditions affecting agriculture with special reference to New Jersey agriculture. This publication is printed by the Extension Division and is mailed to members of the Division and to a number of individual farmers. There have also been a number of requests for this publication from other than New Jersey people. Judged from comments received and requests to be placed on the mailing list, it has evidently become a serviceable publication.

---

[1] N. J. Agr. Exp. Sta. Bul. 438.

STUDY OF MILK DISTRIBUTION

On February 1 to 5, Professor Keller, accompanied by county agents Ellwood Douglass, Douglas Evans, and Charles Thompson; dairy specialist E. J. Perry, of the Extension Division, and Paul B. Bennetch, of the State Department of Agriculture, made a trip through Massachusetts for the purpose of studying the farmer-owned milk distributing plants.

Six of these plants were studied and a great deal of useful information as to methods and relative success was obtained. State leader of county agents in Massachusetts, Mr. Parker, rendered very material assistance in arranging the trip to the different plants.

PLANS FOR THE YEAR 1926-1927

The work for the coming year will be largely on the agricultural program project. This will include some research on marketing, the field work in securing farm management records, and the assembling of the material already gathered. There will be a number of publications on the agricultural program after the material is analyzed, after the committees have agreed, and after groups of farmers have discussed the question.

Report of the Department of Agricultural Engineering

E. R. Gross

ORGANIZATION

The agricultural engineering department was organized several years ago, principally for instructional work. Three years ago organized extension work was added and during the past year one definite piece of research work was undertaken, so that now the scope of the department includes resident teaching, extension work, and research.

RESEARCH WORK

Research work was begun in an organized way with the vegetable irrigation survey, which is a joint project, horticulture and agricultural engineering cooperating. The data were collected in about six or seven weeks by two men, one from each department concerned. The information collected is now being prepared for publication.

A joint committee from the American Society of Agronomy, the National Fertilizer Association, the National Association of Farm Equipment Manufacturers, and the American Society of Agricultural Engineers is now studying fertilizer application with reference to crop, machine, and character of fertilizer. The result of this committee's work will probably be the revelation of distinct problems for study. By accumulating data it may also render a service in suggesting changes in present fertilizer distributors, especially with reference to point of application. The writer is serving as chairman of the American Society of Agricultural Engineers subcommittee.

Mr. Lucas is acting as chairman of a committee of the American Society of Agricultural Engineers which is studying the duty of cultivating machinery.

USE OF ELECTRICITY IN AGRICULTURE

New Jersey is ideally located for the study of electric power on farms, especially for vegetable growing, dairying, and poultry raising. The writer is now cooperating with H. B. Weiss, of the State Department of Agriculture, in preparing a data sheet for a survey which Mr. Weiss is to make. The information collected will be available for the use of the agricultural engineering department.

CAMPUS DEVELOPMENT

Possibly no other activities receive more time and thought that may easily go unnoticed than do the engineering features of campus development. Here is much work which requires the greatest of precision. The engineer must see the past, which furnishes the foundations upon which a great future is built. The agricultural engineering department is in a position to furnish, and has furnished, much exact information, maps, sketches, plans, surveys, levels, lines, and data for the proper development of the campus of the Experiment Station and the College of Agriculture. Such work requires days of work with level, chain, and rod or in the office preparing drawings and charts. Supervision is needed to see that the work is done according to specification. Such work has been done this year for buildings, roads, lawns, walks, curbs, gutters, dainage, sewage disposal, and the like. This may be done at the request of the director, assistant director, farm superintendent, or the Buildings and Grounds Committee, of which the writer is a member. A list of the more important of such tasks follows:

Grades for lawn at Baldwin street entrance; levels, lines, and locations for walks, curbs, gutters and drains for parts of main drive; grades, plan and location of walk at Extension Building; grades for parking area at Administration Building; location of drive at rear of Poultry Building; levels for service roads about the campus and farm; complete set of plans for a calf barn for dairy department; levels about the dairy barn; drainage survey for dairy pasture and piggery; drainage survey on the farm; design and advice on septic tanks for the farm. The time required for this work has not been recorded.

Report of the Department of Agronomy

G. W. Musgrave

VARIETY TESTS

Spring Grains

The variety work with spring wheat, barley, and oats has been continued along the same lines as in the preceding year with ten replications of each variety and with suitable border rows on the margins of the plots. The fertilizer treatments are the same as reported in the preceding year. The data are indicated in table 1. The results of the tests reported for the current year in general substantiate those of preceding years, in that the varieties of barley show a definite superiority over oats in yield of grain in pounds per acre. The spring wheat varieties as a whole produce lower yields than oats. The importance of earliness in choosing varieties of oats is again indicated in these data. Those ripening July 13 or later are definitely inferior in yield to the earlier ones.

Winter Grains

The results from the winter grains variety tests, plots of which were laid out and handled in the same manner as those for the spring grains test, are given in table 2. Certain varieties, such as Kanred and Gladden, included in this test have for the past several years indicated their inferior yielding qualities and will be discontinued from further tests. The work has so far indicated some rather distinct differences between different sources of supposedly identical varieties. It is believed that possibly as great a difference exists between strains of certain varieties as between the varieties themselves. This is a matter which will receive further attention in future work.

Forage Crops

In the work with forage crops, the red clover seed source test, the soybean variety test, the timothy strain test, and the alfalfa seed source test are included. In table 3 is given a summary of the results from five seed sources of red clover handled in 1/18-acre plots of five replications each. This work is in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture. Winter killing of the seed of Italian origin has been very outstanding under the latitude of New Brunswick. The seed obtained from Oregon showed the least winter killing of any of the sources included. The yield of seed of English origin, both in green weights and in cured weights, was the highest of any of the sources included in the test.

The soybean variety test included five replications of each of the seven varieties of soybeans and one of cowpeas. Although considerable differences in the yields of the several varieties are indicated,

TABLE 1

Spring Grains Summary, 1925

Variety Number	Variety Name	Rate of planting per acre	Date of planting	Date of heading	Date of ripening	Average height	Total bundle weight per plot	Straw weight per plot	Grain weight per plot	Straw yield per acre	P. E.	Grain yield per acre	P. E.	Color of grain	Test weight per bushel	Grain yields per acre	Relative grain yields
	Wheat																
		pecks				*inches*	*gm.*	*gm.*	*gm.*	*pounds*		*bushels*			*lbs.*	*pounds*	
1	Prelude	5	4-15	6-7	7-1	27.0	663.2	477.2	186.0	1745.98±	63.60	11.34±	.60	Red	57.5	680.54	4
2	Kota	5	4-15	6-16	7-15	29.8	803.8	550.8	253.0	2015.27±	70.97	15.43±	.71	Red	59.5	925.68	1
3	Marquis	5	4-15	6-17	7-14	26.6	621.4	443.4	178.0	1622.31±	65.95	10.85±	.71	Red	56.0	651.27	5
4	Java	5	4-15	6-14	7-13	29.1	725.0	533.3	191.7	1951.24±	69.32	11.69±	.63	Red	55.5	701.39	3
5	Red Bobs	5	4-15	6-14	7-11	27.8	689.9	473.4	216.5	1732.08±	86.84	13.20±	.86	Red	55.5	792.13	2
	Barley																
6	Alpha	10	4-15	6-14	7-5	26.6	1005.7	583.9	421.8	2136.37±	100.60	32.15±	1.27	White	40.5	1543.28	1
7	Featherston	10	4-15	6-11	7-2	26.8	905.5	515.1	390.4	1884.65±	93.04	29.76±	1.25	White	39.0	1428.40	3
8	Manchuria	10	4-15	6-12	7-2	26.6	937.7	560.9	376.8	2052.22±	92.63	28.72±	1.10	White	37.5	1378.64	5
9	Mariout	10	4-15	6-7	7-1	24.6	881.0	459.6	421.4	1681.58±	64.17	32.12±	1.45	White	33.0	1541.82	2
10	Bearded two-row	10	4-15	6-16	7-2	22.6	916.2	527.3	388.9	1929.29±	78.26	29.64±	1.12	White	39.5	1422.91	4
	Oats																
11	Burt Nebr. No. 4	10	4-15	6-16	7-5	29.9	769.7	476.7	293.0	1744.15±	73.91	33.50±	1.60	White	21.0	1072.03	7
12	Burt Nebr. No. 6	10	4-15	6-19	7-9	27.3	911.0	626.1	284.9	2290.77±	63.19	32.58±	1.26	Reddish-brown	20.0	1042.39	9
13	Burt Nebr. No. 8	10	4-15	6-17	7-5	29.6	850.6	538.3	312.3	1969.53±	53.70	35.71±	1.33	Reddish-brown	21.5	1142.64	6
14	Burt Nebr. No. 14	10	4-15	6-14	7-2	25.7	766.9	494.1	272.8	1807.81±	33.79	31.19±	1.44	Brown-black	21.5	998.12	10
15	Texas Red	10	4-15	6-14	7-2	25.9	817.0	495.4	321.6	1812.60±	67.17	36.77±	1.62	Yellow-red	20.0	1176.67	5
16	Kherson Nebr. No. 21	10	4-15	6-16	7-3	26.2	774.0	415.5	358.5	1520.23±	64.11	40.99±	1.76	White	21.5	1311.68	1
17	Kherson C. I. 459	10	4-15	6-15	7-2	25.5	741.38	407.13	334.25	1489.61±	61.07	38.22±	1.65	Yellow	20.0	1222.95	3
18	Iowar C. I. 847	10	4-15	6-18	7-6	26.5	698.4	405.5	292.9	1483.64±	41.24	33.49±	1.55	White	19.5	1071.66	8
19	Fulghum C. I. 708	10	4-15	6-18	7-6	23.0	766.3	430.1	336.2	1573.65±	36.15	38.44±	1.27	Reddish-yellow	18.5	1230.09	2
20	Kanota	10	4-15	6-17	7-5	22.8	770.8	439.8	331.0	1609.14±	38.81	37.85±	1.47	Reddish-yellow	18.5	1211.06	4
21	Cornellian	10	4-15	6-22	7-13	31.1	953.1	685.6	267.5	2508.47±	94.01	30.59±	1.45	White	24.0	978.73	11
22	Crown	10	4-15	6-25	7-15	26.2	955.89	774.33	181.56	2833.12±	120.90	20.76±	1.41	White	17.0	664.29	16
23	New Victor	10	4-15	6-26	7-16	26.3	1054.56	830.56	224.0	3038.85±	163.07	25.61±	1.67	White	14.0	819.57	15
24	Swedish Select C. I. 134	10	4-15	6-23	7-14	27.6	836.33	602.0	234.33	2202.60±	81.89	26.79±	2.14	White	17.0	857.37	14
25	Silvermine C. I. 659	10	4-15	6-23	7-13	27.2	892.8	640.6	252.2	2343.83±	182.16	28.84±	1.45	White	20.0	922.75	12
26	Lincoln C. I. 738	10	4-15	6-22	7-13	28.2	828.4	586.8	241.6	2146.98±	126.58	27.62±	1.59	White	19.0	883.97	13

TABLE 2

Winter Grains, 1924-25

Variety Number	Variety Name	Rate of planting	Date of planting	Date of heading	Date of ripening	Average height	Average total weight per bundle	Average grain weight per bundle	Average straw weight per bundle	Grain yield per acre	P. E. grain	Straw yield per acre	P. E. straw	Test weight per bushel	Rank of grain yields
		pecks				*inches*	*gm.*	*gm.*	*gm.*	*bushels*		*pounds*		*pounds*	
1	Fulcaster C. I. 6162	5	9-25	5-25	6-21	53.1	2016.2	378.1	1638.1	28.82±	.668	7491.06±	143.34	58.0	16
2	China C. I. 180	5	9-25	5-29	6-22	52.6	1891.2	355.4	1535.8	27.09±	.478	7923.24±	214.96	59.0	20
3	Currell C. I. 3326	5	9-25	5-26	6-22	51.0	1902.4	359.7	1542.7	27.42±	.633	7054.80±	191.82	58.5	19
4	Red Rock C. I. 5976	5	9-25	5-26	6-23	47.7	2035.0	446.5	1588.5	34.03±	.707	7264.24±	217.98	59.5	6
5	Purple Straw C. I. 1957	5	9-25	5-24	6-20	47.5	1887.0	370.5	1516.5	28.24±	.791	6934.98±	206.32	59.0	17
6	Fultz C. I. 1923	5	9-25	5-25	6-20	48.4	1882.0	341.9	1540.1	26.06±	.570	7042.91±	187.69	59.5	23
7	Shepherd C. I. 6163	5	9-25	5-28	6-23	49.7	1937.5	405.9	1531.6	30.94±	.827	7004.04±	213.88	59.0	12
8	Mo. Bluestem C. I. 1912	5	9-25	5-27	6-23	49.8	2031.2	354.2	1677.0	26.99±	.514	7668.95±	143.49	58.5	21
9	Rod Row C. I. 959	5	9-25	5-29	6-22	52.4	2081.5	402.4	1679.1	30.67±	.757	7678.95±	143.49	58.5	21
10	Ashland	5	9-25	5-27	6-22	46.7	2081.5	402.4	1679.1	30.67±	.757	7678.56±	243.15	59.0	13
11	R 50 (Ky.)	5	9-25	5-24	6-22	46.4	1818.4	328.4	1490.0	25.03±	.453	6813.80±	193.06	59.5	25
12	R 47 (Ky.)	5	9-25	5-25	6-20	49.9	1918.8	502.8	1416.0	38.32±	.718	6475.40±	184.73	58.5	1
13	Leap's Prolific	5	9-25	5-26	6-22	48.0	1920.2	349.4	1570.8	26.63±	.864	7183.30±	183.56	57.5	22
14	Penn. 44	5	9-25	5-29	6-23	53.1	1904.7	480.3	1424.4	36.61±	.627	6513.81±	185.13	59.0	4
15	Dawson's Golden Chaff	5	9-25	5-28	6-23	45.4	1931.7	406.0	1525.7	30.94±	.817	6977.06±	163.48	59.0	11
16	Forward	5	9-25	5-27	6-22	48.0	1846.7	482.7	1364.0	36.79±	1.400	6237.60±	235.50	58.0	3
17	Red Wave	5	9-25	5-28	6-23	49.4	1913.9	417.8	1496.1	31.84±	.874	6841.70±	231.92	58.5	9
18	Four Row Fultz	5	9-25	5-28	6-22	46.5	1960.2	452.6	1507.6	34.50±	1.103	6894.28±	206.91	57.0	5
19	Currell's Prolific	5	9-25	5-25	6-20	48.8	1721.8	332.6	1389.2	25.35±	.753	6352.84±	141.36	58.0	24
20	Ohio 127	5	9-25	5-27	6-21	47.3	1928.4	418.5	1509.9	31.90±	.991	6904.80±	216.44	57.0	8
21	Kanred	5	9-25	5-30	6-23	42.3	1963.9	407.5	1556.4	31.06±	.770	7117.45±	189.48	57.0	10
22	Gladden	5	9-25	5-29	6-23	50.8	1796.7	391.8	1404.9	29.86±	.561	6424.64±	235.10	60.0	14
23	Leap's No. 12 (N. C.)	5	9-25	5-27	6-21	50.2	1987.8	366.0	1621.8	27.90±	.806	7416.52±	288.80	58.5	18
24	Lancaster-Fulcaster	5	9-25	5-26	6-21	49.5	1975.9	492.3	1483.6	37.52±	.754	6784.53±	224.34	59.0	2
							1862.4	390.4	1472.0	29.76±	.556	6731.49±	188.22	59.0	15
25	Abruzzes	5	9-25	4-26	6-15	63.3	1857.4	434.7	1422.7	35.50±	.830	6506.04±	227.02	53.0	1
26	Rosen	5	9-25	5-15	6-21	64.2	1764.8	381.6	1383.2	31.16±	.827	6325.40±	234.85	50.5	5
27	Bullock's Common	5	9-25	4-28	6-17	69.4	2107.4	422.8	1684.6	34.53±	.944	7703.70±	256.88	52.0	2
28	Davison's Common	5	9-25	4-25	6-17	69.1	2005.7	413.4	1592.3	33.76±	.842	7281.62±	221.68	52.0	3
29	Van Nuys' Common	5	9-25	4-25	6-17	67.5	1980.0	404.8	1575.2	33.05±	.850	7203.42±	174.86	52.0	4
30	Wis. Pedigreed No. 2*	5	9-25	5-15	6-23	67.6	1728.4	328.0	1400.4	29.09±	.996	5720.85±	283.43	51.0	7
31	Swedish Rye	5	9-25	5-10	6-21	65.3	1651.0	356.2	1294.8	26.78±	1.184	5921.15±	333.53	52.0	6
32	Mosida wheat	5	9-25	5-30	6-23	40.3	1746.5	424.1	1322.4	32.32±	.696	6047.36±	219.86	59.5	7

*Poor germination. Only nine plots harvested.

it is necessary to continue this test over a longer period to determine which varieties are superior. One of the difficulties of handling this variety test is to control the rate of seed that, to a certain extent, has varied with the size of the seed of the variety. A more accurate seeding implement is necessary for handling this test. The results are given in table 4.

The comparison of timothy strains has now been carried sufficiently long to indicate definitely the superior yielding qualities of several of these strains. It is, of course, true that the varieties producing the best yields are in many cases also the ones producing the best quality of hay. A completed summary of this work for the entire period of the test can now be prepared.

The work on alfalfa varieties and seed sources during the present year permits reporting data on the first and second cuttings of ten seed sources. The Hardigan obtained from the Michigan Experiment Station appears to be one of the most promising lots included. Attention should be called to the two sources of Grimm, one obtained from the United States Department of Agriculture, giving the highest yield, and one obtained from a commercial source ordinarily considered to be reliable, but which ranked tenth of all lots. The present seedings are to be continued over a sufficient length of time to indicate true differences between the various lots.

TABLE 3

Red Clover Seed Source Test, 1925

Seeded April 26, 1924

Variety	FIRST CUTTING 6-19-25				
	Average height	Winter killing	Average green yield per acre	Average shrinkage	Cured weight per acre
	inches	*per cent*	*pounds*	*per cent*	*pounds*
Oregon, F. C. I. 2438..........	21.5	46.07	5440	51.79	2624.80
Chilean, F. C. I. 2436..........	26.0	58.17	7140	52.86	3365.80
Italian, F. C. I. 2429..........	20.5	74.34	5920	57.85	2495.04
French, F. C. I. 2334..........	24.5	58.01	6360	55.43	2834.91
English, F. C. I. 2252..........	23.0	57.00	7260	52.42	3454.16

CORN BREEDING

The corn breeding work has been continued during the present year. One hundred twenty-seven different lines have been inbred again in sufficient numbers to supply seed for the maintenance of each strain. In addition to the inbreeding, a number of strains, which appeared to have reached an approximate homogeneous condition, have been used in 61 single and 43 double crosses. Out of this total of 104 hybrids, 13 gave yields superior to the selected White Cap strain used as a check. This is the Schmidt's White Cap, a commercial variety of recognized merit.

TABLE 4

Variety Test, Soybean, 1925

Variety	Average height	Date of harvest	Average green weight	Condition of pod	Average shrinkage	Average dry weight	P. E.	Yield of hay per acre	P. E.	Relative yields	Number plots harvested	Character of growth
	inches		*pounds*		*per cent*	*pounds*		*pounds*				
Manchuria 522	36.0	8–24	304.2	½ filled	72.1	84.9	±5.475	5418.7	±349.4	7	4	Erect, stout stems
Peking 556	37.2	9–24	304.2	½ filled	69.9	91.6	±3.212	5846.3	±205.0	5	4	Erect, slender stems
Wilson five 521	51.8	9–24	280.4	½ filled	66.6	93.7	±3.242	5980.3	±206.9	3	5	Slender, twining
Virginia 570	56.5	9–24	282.0	½ filled	66.9	93.3	±3.394	5954.8	±216.6	4	4	Twining, slender stems
Haberlandt 2455	49.2	9–24	312.0	⅓ filled	70.7	91.4	±4.293	5833.5	±274.0	6	4	Erect, stout stems
Lexington 2528	36.5	9–24	362.5	½ filled	72.9	98.2	±1.500	6267.5	± 95.7	1	2	Erect, stout stems
Austin 2529	42.6	9–24	316.0	⅓ filled	69.3	97.0	±3.953	6190.9	±252.3	2	5	Erect, stout stems
New Era Cowpeas	45.7	9–24	280.2	½ ripe	78.5	60.2	±3.883	3842.2	±247.8	8	4	Semi-prostrate stems

SIZE OF POTATO SEED PIECE AND RATE OF PLANTING

The rate of planting work was continued during the present year with the same series of treatments used in the preceding year and with three replications of each treatment. The plots consisted of three rows, 100 feet long. In addition to the usual harvesting determinations, an individual hill study was made for biometrical and statistical analyses. Approximately one hundred hills (in three cases, one or two hills less than this number) were harvested individually and a record was obtained of the number of tubers per hill and the individual tuber sizes. Although the statistical studies have not been completed and will not be completed until data are available for at least one succeeding year, a summary of results is given in table 7. Further details of these individual hills are given in tables 8 and 9. It is of particular interest to note that the percentage of tubers weighing less than 15 gm., from 16 to 30 gm., and from 31 to 45 gm., does not vary greatly with the size of seed piece and the rates of planting. In all cases, over 93.5 per cent of the total weight was in the class of 45 gm. and over. In no case did this class include more than 97.75 per cent of the total weight. Present data would indicate, therefore, that closer spacing than normal would not greatly increase the percentage by weight or tubers in the smaller classes. This is a matter for further corroboration.

TABLE 5

Timothy Strain, 1925

Number	Variety	Date of seeding	Date of heading	Date of full bloom	Average height	Date of harvest	Average green weight
					inches		*pounds*
1	F. C. I. 9327..........	9- 4-24	6-10	6-14	26	6-22	43
2	Cornell 4051	9- 4-24	6-14	6-19	23	6-30	37
3	F. C. I. 6807..........	9- 4-24	6-15	6-18	24	6-30	52
4	Ordinary	9- 4-24	6-16	6-20	23	6-30	51
5	F. C. I. 3937..........	9- 4-24	6-25	6-30	20	7-9	44
6	Cornell 4123	9-23-24	6-11	6-16	24	6-22	57
7	Cornell 4059	9- 4-24	6-24	6-28	23	7-9	55
8	F. C. I. 9400..........	9- 4-24	6-24	6-30	22	7-9	50
9	F. C. I. 6408	9- 4-24	6-26	7-3	22	7-14	45

Number	Variety	Average shrinkage	Average cured weight	Cured hay per acre	P. E.	Relative yields
		per cent	*pounds*	*pounds*		
1	F. C. I. 9327	40.27	25.68	2796.6	±227.78	6
2	Cornell 4051	49.17	18.81	2048.4	±218.46	9
3	F. C. I. 6807	49.17	26.43	2878.2	±255.52	5
4	Ordinary	50.67	25.16	2739.9	±182.83	7
5	F. C. I. 3937	43.62	24.81	2701.8	±154.78	8
6	Cornell 4123	40.50	33.92	3693.9	±236.81	1
7	Cornell 4059	45.34	30.06	3273.5	±248.62	2
8	F. C. I. 9400	46.36	26.82	2920.7	±212.44	3
9	F. C. I. 6408	40.70	26.69	2906.5	±253.87	4

TABLE 6

Alfalfa Seed Source, 1925

Number	Variety	Origin	Date of full bloom	FIRST CUTTING 6-19 Average plant height	 Green weight per plot	 Shrinkage	 Cured weight per plot	 Cured weight per acre
				inches	*pounds*	*per cent*	*pounds*	*pounds*
1	Common	Kansas	6-11	28	81.5	54.5	36.9	2952
2	Common	S. Dak.	6-11	28	78.5	55.6	34.8	2784
3	Common	Mont.	6-11	27	76.8	53.9	35.4	2832
4	Common	"Quaker"	6-11	27	69.3	53.9	32.2	2576
5	Grimm	U. S. D. A.	6-11	27	84.0	54.2	38.2	3056
6	Le Beau	Mich.	6-11	30	76.3	53.7	35.3	2824
7	Hardigan	Mich.	6-11	28	87.0	55.2	39.0	3120
8	Cossack	S. Dak.	6-11	28	79.5	53.4	36.4	2912
9	Province	France	6-11	27	70.3	54.2	31.7	2536
10	Grimm.	(Com., Source "A")	6-11	26	64.0	56.1	27.7	2216

	SECOND CUTTING 8-12						BOTH CUTTINGS			
Number	Date of full bloom	Average plant height	Green weight per plot	Shrinkage	Cured weight per plot	Cured weight per acre	Cured weight per plot	Cured weight per acre	P. E.	Rank
		inches	*pounds*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*		
1	8-3	13	65.8	68.9	20.4	1632	57.3	4584	± 48.40	6
2	8-3	14	66.3	68.0	21.2	1696	56.0	4480	± 62.38	7
3	8-2	13	71.3	68.1	22.0	1760	57.4	4592	±139.91	5
4	8-2	14	68.0	68.3	21.5	1720	53.7	4296	±248.22	8
5	8-1	15	76.3	68.4	24.1	1928	62.3	4984	±243.30	1
6	7-30	16	72.8	67.7	23.5	1880	58.8	4704	±224.09	4
7	7-29	14	69.3	68.7	21.7	1736	60.7	4856	±228.74	2
8	7-29	14	77.3	69.9	23.3	1864	59.7	4776	±191.34	3
9	8-1	13	59.3	69.0	18.4	1472	50.1	4008	±243.30	9
10	7-30	14	66.3	68.1	20.9	1672	48.6	3888	± 66.04	10

TABLE 7

Yields from Individual Hill Harvests—Size of Potato Seed Piece Project

Plot	Size of seed piece	Space between	Total yield	Number hills weighed	Average yield per hill	Plants per 100 feet	Yield per 100 feet
	ounces	*inches*	*gm.*		*gm.*		*gm.*
A	½	12	23,995	100	239.950	100.00	23,995
B	½	9	31,070	100	310.700	133.33	41,425
C	1	18	38,098	100	380.980	66.66	25,396
D	½	7½	26,145	98	266.785	160.00	42,685
E	1	15	39,772	100	397.720	80.00	31,817
F	1½	22½	47,794	100	477.940	53.33	25,488
G	½	6	22,944	99	231.757	200.00	46,351
H	1	12	34,585	100	345.850	100.00	34,585
I	1½	18	40,060	100	400.600	66.66	26,703
J	1	9	28,242	100	282.420	133.33	37,655
K	1½	13½	40,221	100	402.210	88.88	35,748
L	1½	9	31,349	99	316.656	133.33	42,219

Table 8

Distribution of Tubers in Size Classes—Individual Hill Harvests

Plot	Total number tubers	Under 15 gm.		16-30 gm.		31-45 gm.	
		Weight	Number	Weight	Number	Weight	Number
		gm.		*gm.*		*gm.*	
A	269	206	23	446	20	872	23
B	330	239	25	363	17	839	22
C	371	175	21	589	25	1008	26
D	253	98	12	466	20	669	18
E	351	182	25	215	9	491	14
F	445	281	39	598	25	1072	28
G	237	139	19	373	16	700	18
H	330	185	25	429	20	681	17
I	387	204	24	387	16	1285	31
J	313	173	23	579	25	1082	28
K	383	136	16	560	27	971	27
L	331	166	22	220	10	995	26
Total	4000	2184	274	5225	230	10665	278

Plot	Over 45 gm.		Total yield	Average yield per hill	Tuber yield average per hill	Number of hills
	Weight	Number				
	gm.		*gm.*	*gm.*	*gm.*	
A	22,471	203	23,995	239.95	94.42	100
B	29,629	266	31,070	310.70	99.84	100
C	36,326	299	38,098	380.98	109.86	100
D	24,912	203	26,145	266.78	114.30	98
E	38,884	301	39,772	399.72	125.00	100
F	45,843	353	47,794	477.94	121.98	100
G	21,702	184	22,914	231.75	110.51	99
H	33,290	268	34,585	345.85	118.36	100
I	38,264	316	40,140	401.40	114.11	100
J	26,408	237	28,242	282.42	102.46	100
K	38,554	313	40,221	402.21	115.35	100
L	29,968	273	31,349	316.66	105.39	99
Total	386,251	3,245	404,325	1,055.56	1,331.58	1196

GRASS AND TURF WORK

In the permanent grass gardens originally laid out for observation and classroom study in the Agricultural College, a series of simple treatments was begun during the present year for the purpose of obtaining information on the relative permanency of the various species and varieties when clipped and when allowed to mature; also to determine the relative response of these several species under acid and under alkaline soil conditions. For this purpose the plots were subdivided lengthwise and one half of each was clipped and regularly mowed with the lawnmower. The other half was allowed to mature. after which it was cut with the mower and harvested as hay. The plots were subdivided in the opposite direction, one half of each being given a treatment of nitrate of soda and the other half a treat-

TABLE 9

Percentage of Total Number of Tubers in Classes Specified

Plot	Total number tubers	Under 15 gm.		16-30 gm.		31-45 gm.		45 and over	
		Number	Weight	Number	Weight	Number	Weight	Number	Weight
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
A	269	8.55	.85	7.43	1.85	8.55	3.63	75.46	93.64
B	330	7.57	.76	5.15	1.16	6.66	2.70	80.60	95.36
C	371	5.66	.45	6.73	1.54	7.00	2.64	80.50	95.34
D	253	4.74	.37	7.90	1.78	7.11	2.55	80.23	95.28
E	351	7.12	.45	2.56	.54	3.98	1.23	85.75	97.76
F	445	8.76	.58	5.61	1.25	6.29	2.24	79.32	95.91
G	237	8.01	.60	6.75	1.62	7.59	3.05	77.63	94.71
H	330	7.57	.53	6.06	1.24	5.15	1.96	81.21	96.25
I	387	6.20	.50	4.13	.96	8.01	3.20	81.65	95.32
J	313	7.34	.61	7.98	2.05	8.94	3.83	75.71	93.50
K	383	4.17	.33	7.04	1.39	7.04	2.41	81.72	95.85
L	331	6.64	.52	3.02	.70	7.85	3.17	82.47	95.59
Av'ge		6.85	.54	5.75	1.29	6.95	2.63	81.12	95.52

TABLE 10

Fertilizer Treatments on Washington Bent Grass

Kinds of Fertilizers	Amount of fertilizer per plot	Amount of fertilizer per acre
	pounds	*pounds*
$(NH_4)_2SO_4$	0.469	204.20
$(NaNO_3)$	0.625	272.25
Ammonium Phosphate	0.569	247.80
$(NaNO_3)$	0.162	70.80
$(NH_4)_2SO_4$	0.119	51.70
Tankage	0.695	302.70
KCl	0.238	104.40
Acid Phosphate	1.430	622.30
Alfalfa Meal	3.855	1680.00
Manure	10.410	4534.60
Bone Meal	1.040	453.00
Sulfur	0.688	299.50
Sulfur	1.376	599.50
$Ca(OH)_2$	7.286	3173.30
$Ca(OH)_2$	14.572	6347.80
NH_4NO_3 (Applied to CaO and S Plots)	0.2925	127.40

ment of ammonium sulfate in equivalent quantities of nitrogen. These treatments are being maintained regularly, and observations and records will be obtained after the effects of the treatments have become apparent. In addition to this work on grasses, the new study in cooperation with the Greens Committee of the United States Golf Association, has been established on several of the important vegetatively propagated strains of bent grass. On the Washington strain the fertilizer treatments shown in table 10 are being established.

During the absence of the agronomist from February, 1926, on leave for commercial work, the experimental work conducted by the department has been under the immediate supervision and direction of Edward E. Evaul. All of the original projects under way in the department have been carried forward according to plan during the present year.

In addition to these, the work on pasture survey, in which an ecological study of the pastures in the important dairy sections of the state is being made with a view to determine the more important factors influencing the carrying capacity of these pastures, is being carried forward by Herbert W. Reuszer. During the present year approximately one hundred thirty-five detail records, including a vegetative map, the carrying capacity, the feed consumption and other related factors, have been obtained on each.

The work on the various grass plots is under the immediate direction of Alwyn C. Sessions.

Report of the Department of Animal Husbandry

FRANK G. HELYAR

BUILDINGS AND EQUIPMENT

The sheep barn has been completed, fences enclosing two acres for sheep lots have been installed, and main drainage lines have been installed in the sheep pastures and in some of the pig lots so that laterals may be installed later and the Judging Pavilion has been completed.

LIVESTOCK

Swine

There are 175 head of swine in the herd, divided as follows:

	BOARS	BROOD SOWS	FAT BARROWS	PIGS
Durocs	2	23	..	80
Hampshires	..	3	..	29
Yorkshires	..	2	..	..
Poland Chinas	..	3	3	12
Berkshires	..	2	..	..
Crossbreds	..	..	..	19
	2	33	3	140

Sheep

The flock of 10 sheep and 9 lambs reported last year has been increased so that there are in the flock at the present time

	RAMS	MATURE EWES	YEARLING EWES	LAMBS
Purebred Shropshires	2	9	4	4
Purebred Hampshires	..	..	2	..
Purebred Dorsets	..	..	2	..
Purebred Rambouillets	..	..	1	..
Grade Shropshires	..	1	1	..
	2	10	10	4

The Shropshire flock was greatly improved through the gift of Miss Ruth McTwombly of Florham Park, New Jersey, of a purebred ram and five ewes. Mr. Waldo Barron of Slippery Rock, Pa., gave the Rambouillet to the college.

Health of Herd

The herd of swine has been quite free from disease during the year. Post mortem examinations of young pigs have not disclosed any definite cases of swine plague (hemorrhagic septicemia) and there have been but two cases of hog cholera, the first being that of a young boar, in August, 1925, that had been given the simultaneous treatment several months before; the other that of a suckling pig, early in June, 1926. The experience of the year increases confidence in the plan of deferring the simultaneous treatment of animals to be retained for breeding purposes until after the market stock is disposed of in the fall, and of protecting the untreated animals during the summer with serum, as may be necessary.

RESEARCH PROBLEMS

During the year, five problems were studied. A report of these is given in the following pages.

A Study of Farrowing Records

Profit from swine is largely affected by the number of pigs that can be successfully weaned and raised. It is also affected by the time of weaning. The pigs that are ready for market in the latter part of October usually bring more money than those that go to market in competition with the bulk of the western shipments in November and December. To get the young pigs well started in late February and March with the severe changes in temperature and humidity that take place during this period and with the inability to get them out on the soil presents many problems.

During the last three years the department has been making a careful study of the farrowing performances of the brood sows and of the factors that influence the number of pigs weaned and raised.

The results of this year's study are included with those of 1924 and 1925 in table 1.

TABLE 1

Farrowing Performance of Brood Sows and Factors Inflencing the Number of Pigs Weaned and Raised

	1924	1925	1926
Number of Litters	24	19	21
Pigs Born	252	189	241
Average Number in Litter	10.5	9.9	9.27
Pigs Born Dead	26	21	25
Per Cent Born Dead	10.3	11.1	10.3
Pigs Dying First 14 Days*	78	25	53
Per Cent Dying First 14 Days	30.9	13.2	21.9
Pigs Dying After 14 Days	56	30	15
Per Cent Dying After 14 Days	22.0	15.8	6.2
Number Weaned	125	107	148
Average No. Weaned Per Litter	5.2	5.7	5.69
Per Cent of Pigs Weaned	49.6	56.6	61.4

*Of the 53 pigs dying during the first 14 days after birth, in 1926, 12 were killed by their dams, 20 were weak, and 23 were sick.

A study of the table will show the following facts:

That in 1926 the average litter had nearly one pig less than in 1924 or 1925.

That about the same percentage of pigs was born dead each year.

That in 1926 relatively fewer pigs died during the first 14 days than in 1924, but more than in 1925.

That in 1926 over 70 per cent fewer pigs died after 14 days than in 1924, and 50 per cent less than in 1925.

That a larger percentage of pigs was weaned in 1926 than in the two previous years.

The great reduction in mortality after the pigs are two weeks old between 1924 and 1926 indicates that this phase of the problem is being met. As stated in last year's report this decrease has followed the use of a definite method of reducing the infestation of the young pigs by round worm (*Ascaris Suis*) which takes place under ordinary conditions as soon as the pigs suckle.

The mortality during the first two weeks presents another problem, that of finding methods of management that will protect the pigs during this period against the vitiating influence of the weather conditions of the season or of any other factors that may appear as the work progresses.

A Study of the Effect of Protozyme on the Utilization of Food by Swine[1]

Protozyme is a commercial product containing enzymes which split, or digest, both carbohydrates and proteins. At this station, experimental results with poultry seem to bear out the contention that Protozyme, when added to the usual rations, will so assist in the digestion and assimilation of the food that increased gains in body weight or in production ensue.

The object of this experiment was to determine the effect of Protozyme on the utilization of food by swine. The work was divided into three parts: (1) with suckling pigs; (2) with weanling pigs, and (3) with shotes being fed out for market.

Parts I and II—Suckling Pigs

Duroc-Jersey and Yorkshire-Duroc crossbred pigs, 4 weeks old, which had learned how to eat grain, were selected for this part of the work. They were not removed from their dams but continued to nurse until they were weaned at 8 weeks old.

Lot I, consisting of 9 pigs in two litters was used as a check, receiving the basal ration consisting of the following:

Corn Meal	60 pounds
Red Dog Middlings	30 pounds
60% Digester Tankage	5 pounds
Skim Milk Powder	5 pounds

Lot II, consisting of 16 pigs in two litters, received in addition, 1 per cent of Protozyme.

Lot III, consisting of 16 pigs in two litters, received in addition, 2 per cent of Protozyme.

Lot IV, consisting of 18 pigs in two litters, received in addition, 3 per cent of Protozyme.

Lot V, consisting of 8 pigs in one litter, received in addition, 4 per cent of Protozyme.

Lot VI, consisting of 13 pigs in two litters, received in addition, 5 per cent of Protozyme.

The Protozyme in each case was mixed with the basal ration and the mixture self-fed.

The pigs were weighed each week and when they were eight weeks old were weaned.

Tables 2 to 7, inclusive, show the initial, weekly, and final weights of each individual in each group as well as the total gain, the daily gain per pig, the average daily gain, the total feed consumed, and the feed consumed per pound of gain.

After weaning, the pigs were continued 28 days longer in the same groups and fed the same rations. Tables 8 to 13, inclusive, give the data for this period of feeding, whereas tables 14 and 15 summarize the results of the entire 49 days feeding before and after weaning.

---

[1] This project was planned and carried out by W. C. Skelley.

TABLE 2

Showing Feed Consumed and Weights Attained During the Last Three Weeks Before Weaning

Check Lot—No Protozyme*

SEX	WEIGHTS OF PIGS BY WEEKS					
	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
S	12.4	16.3	20.8	21.5	9.1	.43
B	15.0	18.0	22.0	25.0	10.0	.47
S	12.7	16.7	21.5	25.0	12.3	.58
B	16.0	20.5	26.7	30.0	14.0	.66
B	13.0	14.5	19.3	21.4	8.4	.40
S	13.2	17.8	22.0	27.5	14.3	.68
B	23.9	28.3	36.5	43.7	19.8	.94
B	23.5	28.6	35.5	41.0	17.5	.83
S	20.7	24.8	26.5	30.4	9.7	.46

	lbs.
Total gain of litter in 21 days..........	115.1
Average gain per pig in 21 days.........	12.6
Average daily gain per pig..............	0.6
Total feed consumed in 21 days.........	33.0
Feed consumed per pound of gain........	0.286

TABLE 3

Showing Feed Consumed and Weights Attained During the Last Three Weeks Before Weaning

Protozyme—1 Per Cent

SEX	WEIGHTS OF PIGS BY WEEKS					
	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B	17.0	20.9	25.3	29.7	12.7	0.60
S	17.8	23.1	28.8	35.5	17.7	0.84
B	17.3	22.0	27.3	33.7	16.4	0.78
B	19.8	25.5	30.7	38.3	18.5	0.88
S	24.5	31.2	37.3	41.8	17.3	0.82
S	21.9	26.8	33.5	40.0	18.1	0.86
S	18.1	19.8	24.8	30.0	11.9	0.56
B	14.6	19.1	22.5	25.6	11.0	0.52
B	13.0	14.2	17.0	19.0	6.0	0.28
S	25.4	29.8	35.0	39.0	13.6	0.64
S	23.5	29.3	35.8	44.8	21.3	1.01
B	24.7	31.0	37.0	44.4	19.7	0.93
S	27.7	36.3	42.3	48.5	20.8	0.99
B	23.6	29.8	33.7	39.0	15.4	0.73
S	26.6	32.0	35.5	40.9	14.3	0.68
B	22.8	28.8	35.0	41.0	18.2	0.86

	lbs.
Total gain of litter in 21 days...........	252.9
Average gain per pig in 21 days.........	15.7
Average daily gain per pig..............	0.74
Total feed consumed in 21 days.........	110.0
Feed consumed per pound of gain.......	0.43

TABLE 4

Showing Feed Consumed and Weights Attained During the Last Three Weeks Before Weaning

Protozyme—2 Per Cent

	WEIGHTS OF PIGS BY WEEKS					
SEX	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B	14.5	18.8	24.4	29.0	14.5	.69
S	11.2	15.5	21.0	25.3	14.1	.67
S	12.5	16.3	21.0	27.5	15.0	.71
S	19.4	23.8	30.0	33.7	14.3	.68
S	20.0	26.5	33.2	42.0	22.0	1.04
S	16.6	19.0	23.3	29.5	12.9	.61
S	12.3	15.2	18.3	23.1	10.8	.51
S	15.5	20.2	23.4	27.4	11.9	.56
B	18.0	22.2	29.5	35.0	17.0	.80
B	18.3	22.0	26.8	30.8	12.5	.59
S	16.6	21.4	27.0	32.0	15.4	.73
S	15.5	20.0	25.7	30.0	14.5	.69
B	16.1	21.3	26.6	29.5	13.4	.63
B	17.1	20.3	23.5	27.2	10.1	.48
B	11.9	15.0	18.5	22.7	10.8	.51
S	13.4	16.5	20.7	23.2	9.8	.46

	lbs.
Total gain of litter in 21 days............	219.0
Average gain per pig in 21 days.........	13.7
Average daily gain per pig..............	0.65
Total feed consumed in 21 days..........	89.0
Feed consumed per pound of gain........	0.406

TABLE 5

Showing Feed Consumed and Weights Attained During the Last Three Weeks Before Weaning

Protozyme—3 Per Cent

	WEIGHTS OF PIGS BY WEEKS					
SEX	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B	15.3	20.0	24.2	30.3	15.0	.71
S	12.8	16.7	20.4	27.3	14.5	.69
S	13.4	17.8	22.8	30.0	16.6	.79
B	17.8	22.0	26.0	33.5	15.7	.74
S	17.3	20.0	25.8	33.5	16.2	.77
B	9.1	11.5	14.5	20.0	10.9	.51
S	19.0	23.4	29.6	38.0	19.0	.90
B	15.7	18.6	23.8	30.7	15.0	.71
S	17.3	21.4	27.2	35.5	18.2	.86
S	19.6	23.0	28.6	37.0	17.4	.82
S	20.0	26.3	31.5	38.5	18.5	.88
S	16.8	22.5	29.3	36.5	19.7	.93
B	11.8	14.2	16.1	19.5	7.7	.36
S	22.0	27.2	33.7	41.3	19.3	.91
S	18.5	23.6	31.1	38.8	20.3	.96
B	13.4	17.4	22.0	26.8	13.4	.63
B	16.8	21.0	26.5	31.4	14.6	.69
S	18.7	21.2	26.3	31.0	12.3	.58

	lbs.
Total gain of litter in 21 days...........	284.3
Average gain per pig in 21 days........	15.7
Average daily gain per pig..............	0.74
Total feed consumed in 21 days........	122.0
Feed consumed per pound of gain.......	0.429

TABLE 6

Showing Feed Consumed and Weights Attained During the Last Three Weeks Before Weaning

Protozyme—4 Per Cent

	WEIGHTS OF PIGS BY WEEKS					
SEX	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B	16.7	22.2	28.3	35.5	18.8	.89
S	21.3	26.1	34.0	42.0	20.7	.98
B	10.4	10.8	12.6	13.4	3.0	.14
S	17.9	20.8	23.5	28.8	10.9	.51
B	15.9	17.9	22.4	28.0	12.1	.57
S	14.9	19.0	24.2	31.0	16.1	.76
B	14.3	16.6	19.1	21.7	7.4	.35
B	12.5	16.0	18.5	20.0	7.5	.35

	lbs.
Total gain of litter in 21 days............	96.5
Average gain per pig in 21 days........	12.6
Average daily gain per pig.............	0.6
Total feed consumed in 21 days........	30.5
Feed consumed per pound of gain.......	0.316

TABLE 7

Showing Feed Consumed and Weight Attained During the Last Three Weeks Before Weaning

Protozyme—5 Per Cent

	WEIGHTS OF PIGS BY WEEKS					
SEX	Fifth Week	Sixth Week	Seventh Week	Eighth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
S	13.5	18.0	23.0	28.8	15.3	.72
S	7.6	10.0	13.5	17.4	9.8	.46
S	9.2	10.6	14.5	21.4	12.2	.58
S	15.7	18.7	25.0	32.3	16.6	.79
B	15.5	19.0	24.8	31.7	16.2	.77
B	19.0	22.0	28.0	32.5	13.5	.64
S	20.0	24.1	29.8	34.5	14.5	.69
B	19.5	22.2	27.1	33.5	14.0	.66
S	16.7	19.2	22.7	27.0	10.3	.49
S	16.0	19.8	24.0	29.2	13.2	.62
S	13.4	16.0	20.8	27.0	13.6	.64
S	12.0	15.2	19.7	24.9	12.9	.61
S	12.6	16.8	23.0	29.4	16.8	.80

	lbs.
Total gain of litter in 21 days...........	178.9
Average gain per pig in 21 days.........	13.7
Average daily gain per pig..............	0.65
Total feed consumed in 21 days..........	80.0
Feed consumed per pound of gain........	0.44

TABLE 8

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Only, Check—No Protozyme

	WEIGHT OF PIGS BY WEEKS						
SEX	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
S ...	21.5	22.3	23.1	26.4	28.2	6.7	.23
B ...	25.0	26.8	31.0	34.7	36.8	11.8	.42
S ...	25.0	26.0	27.0	30.6	33.5	8.5	.30
B ...	30.0	32.5	36.0	41.0	44.8	14.8	.52
B ...	21.4	26.4	28.5	31.0	34.0	12.6	.45
S ...	27.5	28.4	30.3	33.3	33.5	6.0	.21
B ...	43.7	43.5	46.0	53.0	57.6	13.9	.49
B ...	41.0	41.7	43.8	45.0	46.8	5.8	.20
S ...	30.4	32.4	35.5	40.8	45.0	14.6	.52

	lbs.
Total gain of litter in 28 days	94.7
Average gain per pig in 28 days	10.52
Average daily gain per pig	0.375
Total feed consumed in 28 days	337.0
Average amount of feed consumed per pig	37.4
Feed consumed per pound of gain	3.55

TABLE 9

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Plus Protozyme—1 Per Cent

	WEIGHT OF PIGS BY WEEKS						
SEX	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B ...	29.7	34.1	36.8	38.2	41.5	11.8	.42
S ...	35.5	40.2	41.0	44.9	48.2	12.7	.45
B ...	33.7	37.6	41.8	46.3	52.0	18.3	.65
B ...	38.3	43.4	48.0	53.0	58.3	20.0	.71
S ...	41.8	48.4	51.8	58.7	61.5	19.7	.70
S ...	40.0	43.5	46.8	51.8	56.8	16.8	.60
S ...	30.0	34.1	36.0	37.0	38.8	8.8	.31
B ...	25.6	30.7	33.2	36.8	38.5	12.9	.46
B ...	19.0	22.3	24.0	26.0	27.8	8.8	.31
S ...	39.0	43.2	47.5	53.0	58.3	19.3	.68
S ...	44.8	48.1	52.0	55.0	60.0	15.2	.54
B ...	44.4	48.3	51.0	56.7	62.0	17.6	.62
S ...	48.5	56.7	63.0	70.0	77.0	28.5	1.01
B ...	39.0	41.9	44.8	50.0	54.5	15.5	.55
S ...	40.9	44.6	46.5	50.8	57.0	16.1	.57
B ...	41.0	43.7	46.5	51.2	56.0	15.0	.53

	lbs.
Total gain of litter in 28 days	257.0
Average gain per pig in 28 days	16.06
Average daily gain per pig	0.573
Total feed consumed in 28 days	682.0
Average amount of feed consumed per pig	42.06
Feed consumed per pound of gain	2.65

TABLE 10

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Plus Protozyme—2 Per Cent

SEX	WEIGHT OF PIGS BY WEEKS						
	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B ...	29.0	31.6	33.8	36.7	40.6	11.6	.41
S ...	25.3	27.1	30.3	35.0	40.2	14.9	.53
S ...	27.5	30.0	32.6	36.7	40.7	13.2	.47
S ...	33.7	36.0	40.9	45.0	49.3	15.6	.55
S ...	42.0	46.0	48.1	55.0	56.3	14.3	.51
S ...	29.5	31.7	35.5	39.0	42.1	12.6	.45
S ...	23.1	24.0	26.2	30.0	33.0	9.9	.35
S ...	27.4	30.5	32.1	37.5	41.3	13.9	.49
B ...	35.0	39.7	41.4	42.6	45.1	10.1	.36
B ...	30.8	34.3	35.0	38.0	39.5	8.7	.31
S ...	32.0	35.3	39.2	43.0	49.1	17.1	.61
S ...	30.0	33.2	36.1	38.8	43.4	13.4	.47
B ...	29.5	33.0	32.3	34.8	37.7	8.2	.29
B ...	27.2	28.3	30.0	31.7	31.5	4.3	.15
B ...	22.7	26.0	27.7	31.3	31.3	8.6	.30
S ...	23.2	24.7	26.2	30.3	32.7	9.5	.33

	lbs.
Total gain of litter in 28 days	185.9
Average gain per pig in 28 days	11.61
Average daily gain per pig	0.414
Total feed consumed in 28 days	590.0
Average amount of feed consumed per pig	36.8
Feed consumed per pound of gain	3.12

TABLE 11

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Plus Protozyme—3 Per Cent

SEX	WEIGHT OF PIGS BY WEEKS						
	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
B ...	30.3	34.3	40.0	43.3	46.2	15.9	.56
S ...	27.3	29.3	34.5	39.1	42.8	15.5	.55
S ...	30.0	32.7	36.3	41.4	46.1	16.1	.57
B ...	33.5	34.7	39.5	42.0	45.0	11.5	.41
S ...	33.5	35.6	40.5	43.7	50.0	16.5	.58
B ...	20.0	20.8	23.3	26.7	29.4	9.4	.33
S ...	38.0	41.7	47.5	51.7	57.0	19.0	.67
B ...	30.7	34.1	37.0	40.4	44.5	13.8	.49
S ...	35.5	37.4	42.7	46.5	50.3	14.8	.52
S ...	37.0	40.0	45.0	50.0	53.2	16.2	.57
S ...	38.5	45.3	50.0	54.7	59.5	21.0	.75
S ...	36.5	42.3	46.0	49.3	54.0	17.5	.62
B ...	19.5	22.0	23.3	22.0	21.4	1.9	.06
S ...	41.3	45.8	49.7	53.3	59.8	18.5	.66
S ...	38.3	44.7	49.5	53.8	57.7	18.9	.67
B ...	26.8	30.8	33.5	36.2	37.8	11.0	.39
B ...	31.4	37.0	38.5	43.0	47.0	15.6	.55
S ...	31.0	33.5	35.4	38.9	43.5	12.5	.44

	lbs.
Total gain of litter in 28 days	265.6
Average gain per pig in 28 days	14.75
Average daily gain per pig	0.523
Total feed consumed in 28 days	797.0
Average amount of feed consumed per pig	44.2
Feed consumed per pound of gain	3.00

TABLE 12

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Plus Protozyme—4 Per Cent

	WEIGHT OF PIGS BY WEEKS						
SEX	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
B ...	33.5	37.5	42.5	45.5	46.0	10.5	.37
S ...	42.0	46.0	50.4	52.8	55.7	13.7	.48
B ...	13.4	16.0	18.0	19.1	19.3	5.9	.21
S ...	28.8	31.0	34.2	36.8	40.3	11.5	.41
B ...	28.0	31.5	35.7	37.5	40.5	12.5	.44
S ...	31.0	35.0	37.7	40.0	43.2	12.2	.43
B ...	21.7	24.5	25.7	27.5	30.0	8.3	.29
B ...	20.0	22.3	23.4	25.0	27.5	7.5	.26

Total gain of litter in 28 days	82.1
Average gain per pig in 28 days	10.26
Average daily gain per pig	0.366
Total feed consumed in 28 days	253.0
Average amount of feed consumed per pig	31.6
Feed consumed per pound of gain	3.08

TABLE 13

Showing Feed Consumed and Weights Attained During Four Weeks After Weaning

Basal Ration Plus Protozyme—5 Per Cent

	WEIGHT OF PIGS BY WEEKS						
SEX	Eighth Week	Ninth Week	Tenth Week	Eleventh Week	Twelfth Week	Gain	Daily Gain
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
S ...	28.8	35.3	38.0	39.5	43.0	14.2	.50
S ...	17.4	21.5	23.4	25.0	28.0	10.6	.37
S ...	21.4	27.0	29.5	32.4	35.5	14.1	.50
S ...	32.3	39.4	43.0	47.0	51.3	19.0	.67
B ...	31.7	38.5	41.5	45.7	51.7	20.0	.71
B ...	32.5	37.0	40.5	43.2	45.0	12.5	.44
S ...	34.5	39.0	42.2	46.0	50.0	15.5	.55
B ...	33.5	38.5	42.0	43.5	49.6	16.1	.57
S ...	27.0	31.0	34.0	36.0	39.0	12.0	.42
S ...	29.5	34.5	37.5	40.2	43.3	13.8	.49
S ...	27.0	31.0	33.0	35.3	39.3	12.3	.43
S ...	24.9	26.5	28.5	29.2	32.3	7.4	.26
S ...	29.4	30.4	32.8	35.0	38.3	8.9	.31

	lbs.
Total gain of litter in 28 days	176.4
Average gain per pig in 28 days	13.56
Average daily gain per pig	.484
Total feed consumed in 28 days	480.
Average amount of feed consumed per pig	36.9
Feed consumed per pound of gain	2.72

TABLE 14

Summary of Results of Twenty-One Days' Feeding Before Weaning

	Number of Pigs	Average Daily Gain Per Pig	Average Daily Consumption of Food Per Pig	Food Consumed Per Pound of Gain
		lbs.	*lbs.*	*lbs.*
Lot I No Protozyme	9	.60	.174	.286
Lot II Protozyme 1%	16	.74	.318	.43
Lot III Protozyme 2½	16	.65	.267	.406
Lot IV Protozyme 3%	18	.74	.317	.429
Lot V Protozyme 4%	8	.60	.190	.316
Lot VI Protozyme 5%	13	.65	.286	.44

TABLE 15

Summary of Results of Twenty-Eight Days' Feeding After Weaning

	Number of Pigs	Average Daily Gain Per Pig	Average Daily Consumption of Food Per Pig	Feed Consumed Per Pound of Gain
		lbs.	*lbs.*	*lbs.*
Lot I No Protozyme	9	.375	1.33	3.55
Lot II Protozyme 1%	16	.573	1.52	2.65
Lot III Protozyme 2%	16	.414	1.29	3.12
Lot IV Protozyme 3%	18	.523	1.57	3.00
Lot V Protozyme 4%	8	.366	1.13	3.08
Lot VI Protozyme 5%	13	.484	1.32	2.72

The data in these tables, although perhaps indicating that additions of Protizyme gave increased gains both before and after weaning and with less grain per pound of gain after weaning, are too conflicting to be of value in drawing any definite conclusions. Subsequent study of the litters showed that some of them did very much better in the feed lot than others. Then, too, during the period before weaning, the sows may have differed enough in quantity and quality of milk to affect the results greatly.

Part III

In the work with shotes being fed for market two lots of Duroc pigs, 10 each, about sixteen weeks of age, were carefully selected as to size, type, and previous feeding performance.

Lot I, weighing 722 pounds was used as a check, being fed only the basal ration consisting of standard wheat middlings, 60 per cent digestor tankage and shelled corn.

Lot II, weighing 725 pounds was fed an addition of 3 per cent of Protozyme.

Both lots were self-fed, the food being weighed in and out of the feeders each day.

Feeding was begun July 12, 1925, and continued until October 11, when the final weights for the thirteen weeks were taken. Table 16 shows the results of the feeding of this period.

TABLE 16

Consumption of Food, Total Digestible Nutrients, Gains and Cost of Food and Cost Per Pound of Gain for Period July 12 *to October* 11, 1925

	LOT I		LOT II	
	Feed Consumed	T. D. N. Consumed	Feed Consumed	T. D. N. Consumed
	lbs.	*lbs.*	*lbs.*	*lbs.*
Middlings	624	463.96	563.5	418.96
Tankage	229	143.10	221.0	138.11
Corn	4,595	3,586.42	4,425.0	3,453.71
Protozyme	....	......	156.0	......
Total	5,448	4,193.48	5,209.5	4,010.78

Initial weight, *lbs.*	722	725
Final weight, *lbs.*.............	2,085	2,133
Total gain in weight, *lbs.*........	1,363	1,408
Average daily gain per pig, *lbs.*.	1.49	1.54
Total cost	$136.34	$173.54
Cost per lb. of gain.............	$ .100	$ .123

TABLE 17

Showing Consumption of Food, Total Digestible Nutrients, Gains and Cost of Food and Cost Per Pound of Gain for Period October 12 *to November* 8, 1925

	LOT I		LOT II	
	Feed Consumed	T. D. N. Consumed	Feed Consumed	T. D. N. Consumed
	lbs.	*lbs.*	*lbs.*	*lbs.*
Middlings	235	174.72	297.	220.82
Tankage	68.	42.48	77	48.11
Corn	1,930	1,506.38	2,145	1,674.18
Protozume	66.66	......	......	......
Total	2,233	1,723.58	2,519	1,943.11

Initial weight, *lbs*.............	2,085	2,133
Final weight, *lbs*...............	2,670	2,670
Total gain in weight, *lbs*........	585	537
Average daily gain per pigs, *lbs*..	2.08	1.91
Total cost	$74.20	$64.63
Cost per lb. of gain............	$ .126	$ .123

After the pigs were weighed on October 11 the feeding of the lots was reversed in an attempt to find out whether the addition of the Protozyme to the basal ration of lot II had had any influence on the secretions of the digestive glands of the pigs. Lot I received the 3 per cent Protozyme and lot II received only the basal rations. Feeding on this basis was continued until November 8. Table 17 gives the data for this period.

Cost of Feed.—The feeds used in the entire period July 12 to November 8 cost as follows:

Middlings	$35.00 per ton
Tankage	67.00 per ton
Corn	53.00 per ton
Protozyme	.25 per lb.

Figures 1 to 4 summarize and compare the results of the entire feeding period July 12 to November 8.

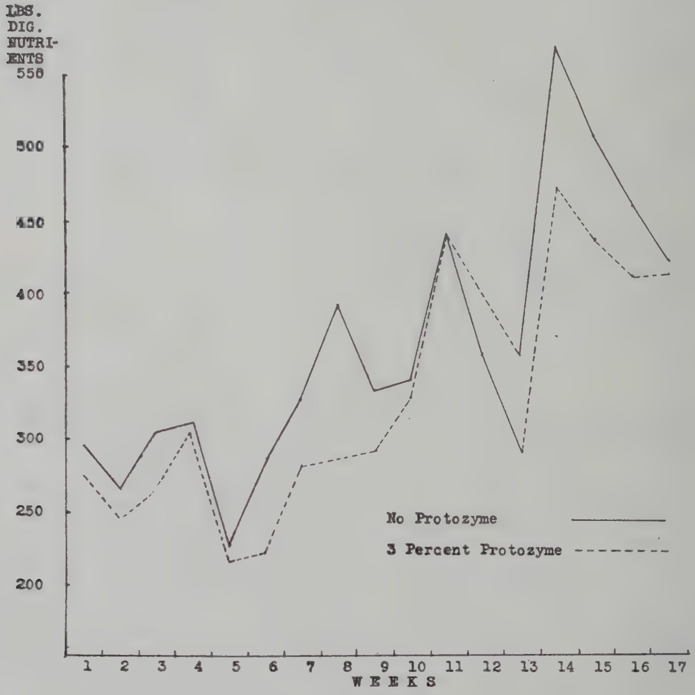


FIG. 1. CONSUMPTION OF TOTAL DIGESTIBLE NUTRIENTS

A study of these and of the cost factors in tables 16 and 17 indicates the following summary:

I. That in the first period of 13 weeks, July 12 to October 11, the pigs receiving no Protozyme consumed slightly more total digestible nutrients than did those receiving Protozyme (Fig. 1.) They gained weight more evenly than did those fed Protozyme. (Fig. 2 and 4.) The pigs in lot II received 3 per cent Protozyme from July 12 to October 11 made a total gain of 45 pounds or 3.3 per cent over those in the check lot. This gain cost 12.3 cents a pound as compared with 10 cents in the case of the check, an increase of 23 per cent.

II. That the pigs fed Protozyme for the period of 13 weeks did not seem to lose the power to eat, digest, and assimilate food when deprived of that material. (Fig. 1 to 4.)

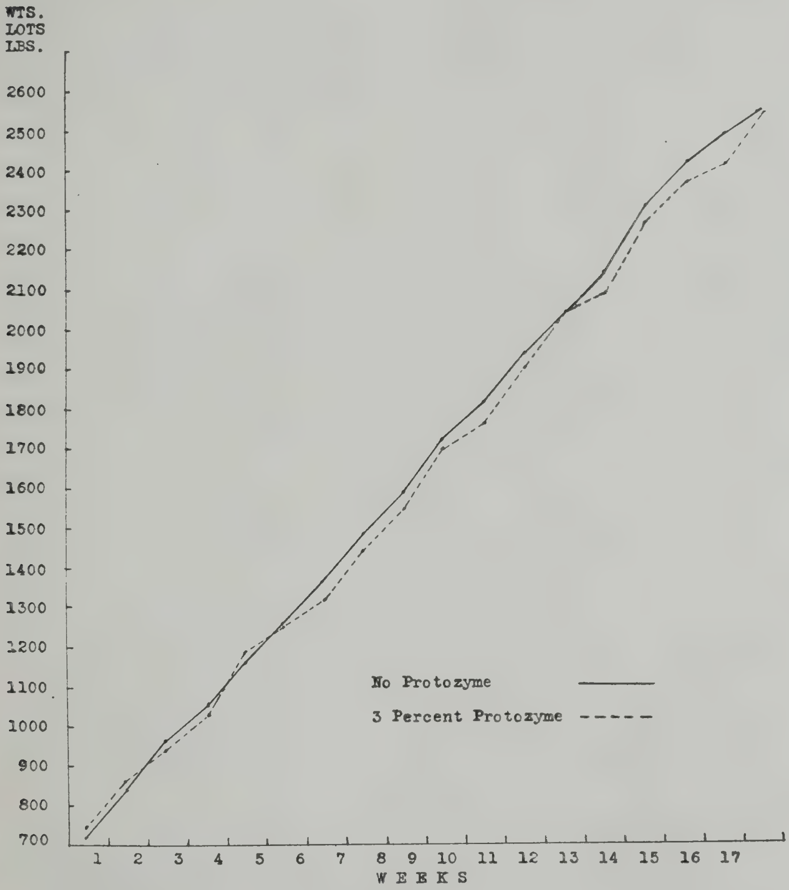


Fig. 2. Weights of Lots by Weeks

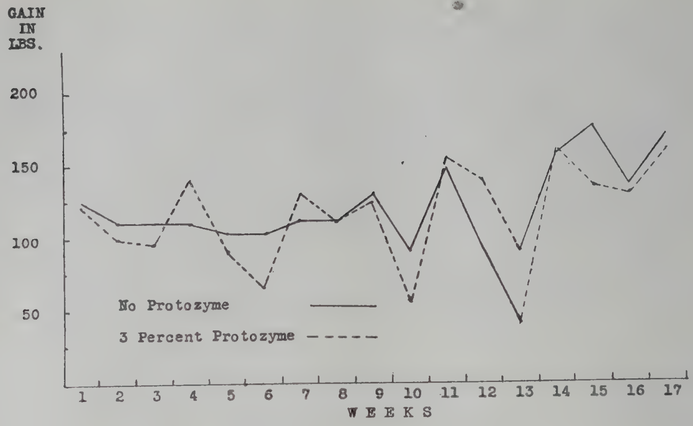


Fig. 3. Gains in Pounds by Weeks

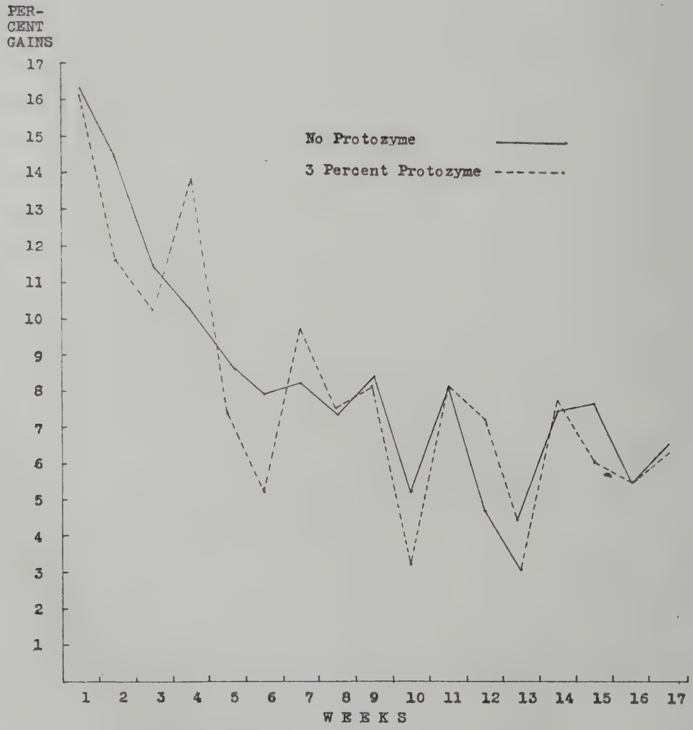


Fig. 4. Per Cent of Gains by Weeks

Conclusion

Protozyme fed to shotes increased slightly the consumption of total digestible nutrients and the gains in weight, but at an increase in cost that makes it doubtful as a practical proposition to recommend to farmers.

Study of Protein Selection by Swine

This project, which was begun in 1924, was carried on during 1925. As stated in the report for 1925, several years' work will be done on this before making any final report.

The following plan of feeding was used during the season of 1925:

SCHEDULE OF FEEDING FOR PROTEIN EXPERIMENT

Group	Pig Number	First Period July13-Aug. 9	Second Period Aug. 10-Sept. 6	Third Period Sept. 7-Oct. 4	Fourth Period Oct. 5-Nov. 2
A	1 2 3	Corn Middlings Alfalfa	Corn Middlings Tankage	Corn Middlings Sk Milk Pwd	Corn Middlings Fish Meal
B	4 5 6	Corn Middlings Tankage	Corn Middlings Alfalfa	Corn Middlings Fish Meal	Corn Middlings Sk Milk Pwd
C	7 8 9	Corn Middlings Fish Meal	Corn Middlings Sk Milk Pwd	Corn Middlings Tankage	Corn Middlings Alfalfa
D	10 11 12	Corn Middlings Sk Milk Pwd	Corn Middlings Fish Meal	Corn Middlings Alfalfa	Corn Middlings Tankage

A Comparison of the Effect of Fishmeal and Tankage on the Rate of Growth and on the Texture and Quality of the Carcass of Swine

This project, which is being conducted in cooperation with the Bureau of Animal Industry of the United States Department of Agriculture and the National Livestock and Meat Board was started during the winter with a preliminary study of the effect of fishmeal and tankage on the chemical composition of the carcass. This work was done by W. C. Skelley with the cooperation of W. T. Russell, of the Department of Agricultural Biochemistry.

Two lots of pigs were fed for 35 days, one lot receiving corn, middlings and fishmeal; the other lot, corn, middlings, and tankage. At the end of the period an animal was selected from each lot and slaughtered and, with the cooperation of the Department of Biochemistry, a chemical analysis was made of the shoulder, side and ham, to determine the moisture and nitrogen content of the muscle tissue.

Tables 18 and 19 show the results of the work. No essential differences are to be noted between the analyses of the two pigs so far as muscle tissue sampled is concerned.

TABLE 18

Results of Analysis of Muscle Tissue of Shoulders, Hams and Sides

	FISH MEAL			TANKAGE		
	Moisture	Nitrogen*	Protein	Moisture	Nitrogen*	Protein
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Shoulder	64.70	4.16	25.97	65.17	4.31	26.92
Side	43.05	4.59	28.71	38.70	4.51	28.19
Ham	65.25	4.65	29.04	64.15	4.54	28.40

*Nitrogen was taken on Dry Basis.

TABLE 19

Results of Analysis of Food Consumed

	Corn	Middlings	Tankage	Fish Meal
Protein Content	7.67	16.82	58.8	56.9

Hogging Down Corn

Lot N, consisting of 3.12 acres, was planted to Reid's Yellow Dent corn, the seed being dropped about 15 inches apart in rows. The last week in November one-half of the field was cut, shocked, husked, and the corn and stalks hauled to the barns and weighed. On the 1.56 acres thus harvested, 6615 pounds of ear corn were produced or an average of 60.6 bushels of shelled corn per acre.

On November 2, 1925, 16 pigs weighing 2830 pounds were placed in a pen and this corn was fed to them by hand. Tankage was fed in a self-feeder. The corn was fed out November 28. The pigs consumed 150 pounds of tankage.

A second lot of pigs, 16 in number, weighing 2855 pounds, was placed in the remaining 1.56 acres of standing corn to "hog it down." Tankage was fed to them in a self-feeder. By November 28 they had cleared the field and 140 pounds of tankage.

Table 20 shows the details of the trial.

The data in table 20 favor the pigs which were hand fed. It must be remembered, however, that the element of cost is not shown.

TABLE 20

Details of "Hogging-Down" Corn Trial

	LOT I Hand-Fed	LOT II In Field
	lbs.	*lbs.*
Corn consumed	6615	6615*
Tankage	150	140
Initial weight	2830	2855
Final weight	3770	3610
Total gain	940	755
Average daily gain per pig	2.26	1.81

*This figure is, of course, only an estimate and is assumed because of the evenness of the stand of corn over the entire field.

At the time of this trial, pigs were selling in New Brunswick at 14 cents per pound. On this basis the two lots produced, during the 28 days, the following:

Lot I	940 lbs. x .14	$131.60
Lot II	755 lbs. x .14	$105.70

Against the $131.60 worth of gain produced by lot I must be charged the cost of harvesting the corn, and the labor of feeding, which was as follows:

	Man Hours	Team Hours
Harvesting, hauling and storing corn and stalks	100	16
Feeding	14	
Totals	114	16
	.40 per hr.	.60 per hr.
	$45.60	$9.60
	9.60	
	$55.20	

When this total is subtracted from the gross returns of lot I the net return from this lot is only $76.40. On this basis, lot II saved in labor the difference between $105.70 and $76.40 or $29.30. In terms of man and team hours, 52 per cent, or 52-man hours, and 8.3 team hours were saved.

Report of the Department of Biology

Thurlow C. Nelson

INTRODUCTION

The work of the past year has been a continuation of earlier studies of the department with especial attention to the relation between temperature and spawning of the oyster and the effects of weather conditions upon the oyster larvae. It has been possible to fix more closely than ever before the "latent period" required after the water reaches a temperature of 20°C. (68°F.) before spawning begins. It is now possible with a fair degree of accuracy to predict from the temperature record when spawning will begin in Barnegat Bay.

True to their promise of last year the two largest planters in Barnegat Bay held their shells on the bank until told when to put them overboard. As a result, over 100,000 bushels of shells were planted just before attachment occurred, and set heavily. Unfortunately, however, practically all of this set died within 24 to 48 hours following attachment.

Dr. George W. Martin, of the department of botany of the University of Iowa, spent a part of the summer of 1925 at the laboratory engaged in a study of the comparative food values of seven species of organisms eaten by the oyster. The results of this work have been published in a bulletin from this station.[1]

By feeding the organisms in pure culture it was demonstrated that the oyster will grow more rapidly when fed upon some than upon others. In no case, however, did growth in the experimental aquaria even approach the growth of spat which were living upon a mixed diet under natural conditions.

Mr. Dumont at the Bivalve Station directed the planting of some 200,000 bushels of shells upon the state beds in Delaware Bay and during the autumn and winter studied the shell movements of oysters at low temperatures and at low specific gravities. His results will be published elsewhere.

The more important of the findings of the year are as follows:

WEATHER AND WATER CONDITIONS

As shown in the report of this department for 1924 the accumulated deficiency in rainfall from 1912 to 1923, inclusive, was 45.42 inches. The first half of 1924 produced an excess of rain which was more than balanced by the deficiency of the second half, October being the driest month on record. The total year's rainfall for the state was 1,71 inches below normal, bringing the accumulated deficiency since 1912 to 47.21 inches, approximately 2 inches in excess of the normal rainfall for an entire year. For the portion of the Sea Coast area, which embraces Barnegat Bay, the close of the year found a deficiency of 11.35 inches.

---

[1] *G. W. Martin* 1926 Utilization of food by young oysters. N. J. Agr. Exp. Sta. Bul. 442.

The year of 1925 continued the subnormal precipitation with 4.39 inches below normal for the state as a whole, bringing the total deficiency since 1912 to 51.7 inches. In the Sea Coast area the deficiency was approximately double this amount. The first five months of 1926 show a deficiency of 4.54 inches for the state as a whole.

Since the specific gravity of the water bears important relations to the setting, food, and growth of oysters, the following very significant paragraph is copied from the Annual Summary for 1925 of the Climatological Data of the Weather Bureau, New Jersey Section (7).

"The past 20 years has shown an accumulated lack of precipitation throughout the state of 90 and more inches, from that of the preceding twenty-year period. While this has no climatic significance, it is an important fact to be considered in *engineering investigations of stream flow, ground water level and water supply.*"[2]

It must be pointed out that the recent developments of the seed producing areas in Barnegat Bay and in the Mullica River have occurred since 1917, over a period of notable lack of rainfall. Should there be a return to a period of years of normal or of excess rainfall, conditions in these areas would be subject to marked changes.

The weather during the spawning season was about normal, save for the first week of June during which all records of the Weather Bureau were broken, with temperatures from 15 to 17°F. above normal. With air temperatures between 90 and 100 F. every day from June 1 to 7, the bottom waters of Barnegat Bay rose from 18°C. on May 31 to 29°C. by June 7.

TEMPERATURE AND SPAWNING OF THE OYSTER

There is general agreement among investigators that spawning of the American oyster (*Ostrea elongata*) occurs only after the temperature of the water has reached 20°C. (68°F.) and has maintained it for some time. Our problem has been to determine so far as possible how long a latent period must elapse after the temperature has reached 20°C. before spawning commences. Also it is necessary to determine whether a high temperature above 20°C. extending over a short period will induce spawning more readily than will a lower temperature maintained over a longer period.

Temperatures were determined (1) by the thermograph on Barnegat Pier from which a continuous temperature record was obtained, and (2) by taking bottom temperatures with an immersion

---

[2] Italics by the author of this paper.

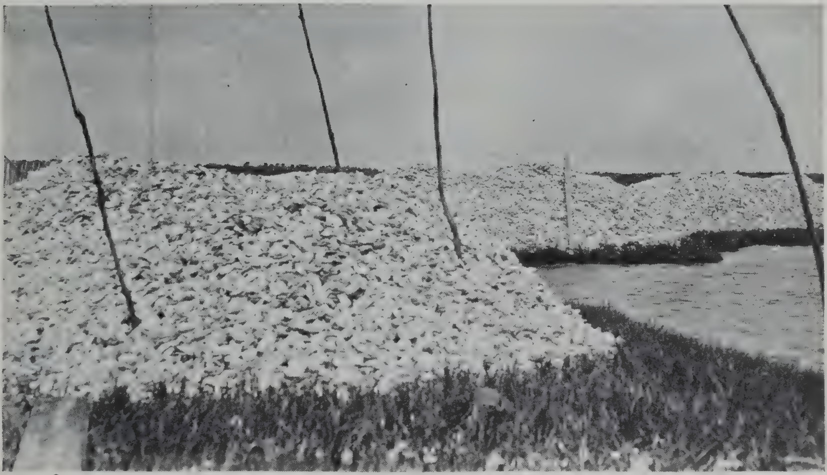


Fig. 1

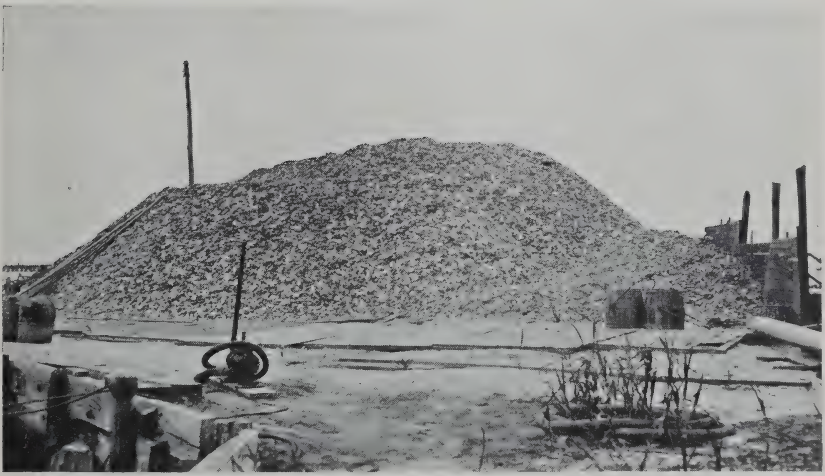


Fig. 2

Plate 1. Shells Ready for Planting

Portion of 100,000 bushels of shells on the shores of Barnegat Bay awaiting word that oyster larvae were abundant in the water.

thermometer over the several beds on the bay. In 1924 the water temperature prior to June 15 remained below 20°C., except for two hours on June 7 when it registered 20.5°C. from 5 to 7 p. m. In 1925 the water temperature prior to May 30 remained below 20°C., except from 2 p. m. May 23 to 4 p. m. May 24, during which time it rose to a maximum of 21.4°C., averaging 20.8°C. for the period.

The actual spawning of the oysters was not observed during either year. The probable time of spawning has been computed from: (*a*) periods of sharpest temperature rise after reaching 20°C.; (*b*) the time of day; (*c*) the stage of the tide; (*d*) the stage of maturity of the oyster larvae taken on the following day in plankton samples.

The long continued observations of J. Nelson have shown that after the spawning tempereature has been attained a sharp rise in temperature is followed by spawning. The author's observations confirm this and show furthermore that spawning is most apt to occur between late afternoon and midnight and during the flood tide.

Sharply rising temperatures induced by transferring ripe oysters to shallow water or to a float where they are exposed to the full glare of the sun will usually induce spawning within a few hours [T. Nelson Rept. for 1921, Prytherch (6)]. The author has actually observed or has recorded on a kymograph natural spawning of the oyster on five occasions. In each instance the process took place late in the day during the late flood tide and with a rising temperature. Upon finding the earliest shelled veligers in the plankton we are justified, therefore, in fixing the spawning time by tracing back approximately 24 hours to a period when a sharply rising temperature coincides with the late flood tide.

Plankton samples taken in June, 1924, indicate that spawning of the oyster occurred on the nineteenth or early on the twentieth. Examination of the thermograph record (fig. 1) shows an increase in temperature at the bottom of Barnegat Bay from 22.6°C. at 8 p. m. of the nineteenth to 23.9°C. by 1 a. m. of the twentieth. The tide commenced to flow approximately at 9 p. m. of the nineteenth, the late flood thus coinciding with the time of maximum temperature and of temperature rise. Midnight of the nineteenth is taken, therefore, as the time of spawning in 1924. The actual temperatures between 10 p. m. of the nineteenth and 2 a. m. of the twentieth varied from 23 to 24°C.

In 1925, plankton samples indicated that spawning commenced on June 3. On this date the temperature of the water at the bottom rose from 23.2°C. at 8 a. m. to 26.1 at 6 p. m. The tide began rising at 3 p. m., with high tide at 8:30 p. m. Spawning occurred probably, therefore, approximately at 6 p. m. A brilliant sun which had shone all day makes this time even more nearly certain. The actual temperatures between 2 p. m. and midnight this date were between 25 and 26°C.

If midnight June 19, 1924, and 6 p. m. June 2, 1925, are taken as the probable hours at which spawning commenced among the oysters in Barnegat Bay, it will be seen that the latent period between the time when the temperature first reached and maintained 20°C. and the onset of spawning, was 96 hours in 1924, and 73 hours in 1925. During the latent period in 1924 the temperature was at 20°C. or above during 84 hours for a total of 157.4 degree hours. In 1925 the temperature was above 20° C. during 64 hours for a total of 166 degree hours. Based upon the data for these

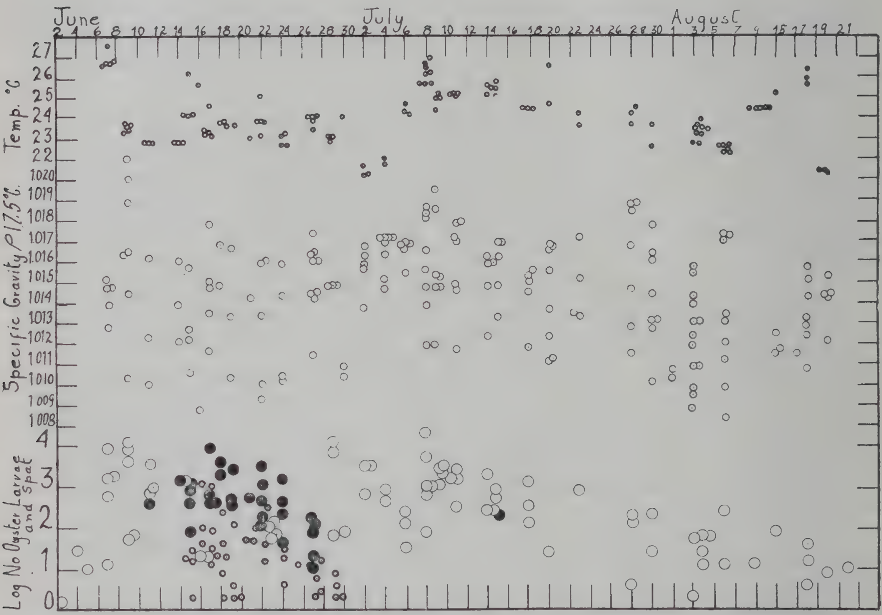


FIG. 1. RESULTS OF WATER EXAMINATIONS MADE BETWEEN BARNEGAT PIER AND THE MOUTH OF CEDAR CREEK DURING THE SUMMER OF 1925

Upper group, small heavy circles, temperature of the water from which the plankton samples were pumped, in degrees Centigrade. Middle group, medium light circles, specific gravity of the water from which the oyster larvae were procured. The figures represent specific gravity at 17.5°C., referred to distilled water at the same temperature; all readings being taken in the laboratory with Knudsen hydrometers. Lower group, large circles, the logarithms of the numbers of oyster larvae of all sizes per 100 liters of water pumped from all depths at the several stations. Circles which fall between 0—1 represent from 0—9 larvae per 100 liters; from 1—2 represent 10—99 larvae, from 2—3 represent 100—990 larvae, from 3—4 represent from 1000—9990 larvae, and 4 or above represent 10,000 or more larvae per sample. The solid black circles represent those samples in which mature oyster larvae bearing pallial eyes formed a portion of the total catch. The small heavy circles represent the logarithms of the numbers of spat which attached to the inner faces of test shells during the preceding 24 hours.

two years it would appear, therefore, that the latent period after reaching 20°C. before spawning occurs, is approximately 160 degree hours.

It must be understood that the temperatures given were taken in the deeper water of the bay; 3 meters for the thermograph and 2 to 3 meters for bottom samples of water. Oysters on shallow flats exposed to bright sunlight were no doubt raised to somewhat higher temperatures at times, though likewise exposed to lower temperatures with the rapid chilling of the shallow waters each night. Since with the ebb and flow of the tide, water from the flats passed the bulb of the thermograph with every tide the temperature record as obtained from the thermograph is considered fairly typical of the temperature picture of the bay as a whole.

FURTHER STUDIES OF THE OCCURRENCE AND BEHAVIOUR OF OYSTER LARVAE

In figure 2 are given the data obtained during 1925 at the several collecting stations lying between Barnegat Pier and the mouth of Cedar Creek. As numbers of oyster larvae taken per 100 liters (roughly 100 quarts) of water varied from 2 to 18,300, in order to bring these numbers into the compass of the chart a logarithmic plot has been employed. It will be seen from this record that

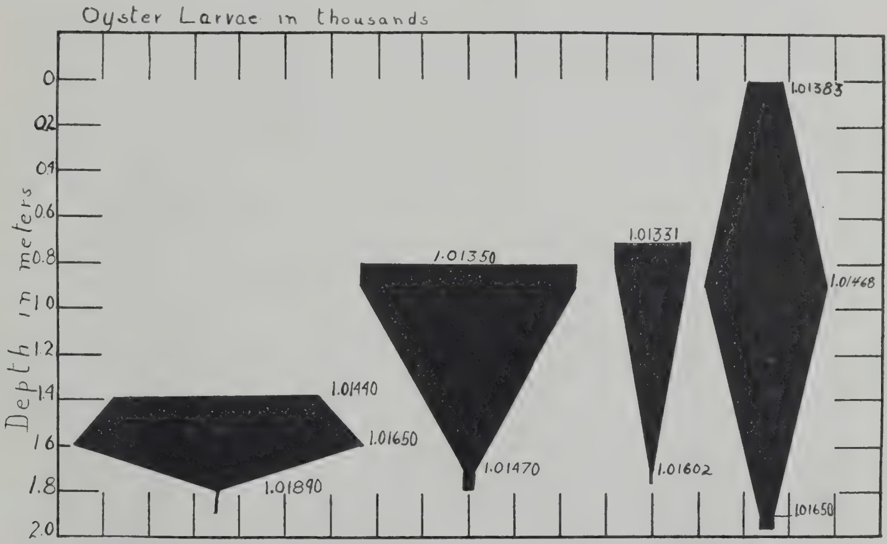


Fig. 2. Vertical Distribution of Oyster Larvae at Station 1, on four different days when preceding calm weather permitted stratification of the water to occur. The specific gravity figures represent the water at 17.5°C. referred to distilled water at the same temperature.

larvae first appeared in numbers on June 4 from the spawning of June 3. The two larvae found on June 2 were apparently from a few oysters in very shoal water which had spawned as a result of the extreme heat.

Large numbers of larvae appeared by June 7 and on the eleventh the first eyed larvae were taken. As explained in the report of 1925, within approximately 24 hours of setting, the mature oyster larvae develops near the center of the mantle on each side a large black pigment spot, known as the pallial eye. The appearance of this conspicuous structure indicates that setting is imminent. Eyed larvae did not appear in numbers until June 14.

It will be seen from figure 1 that with the exception of one sample taken July 15 all eyed larvae occurred between June 11 and 27. The sudden burst of hot weather in early June resulted in earlier spawning than normal and in the quick maturing of the larvae. A second wave of spawning occurred July 7 as shown by the large numbers of straight hinged larvae taken on the eighth. Figure 1 shows that these numbers rapidly diminished and that at the time of the expected set, July 20, only a few remained and none of these was mature. The heavy toll of oyster larvae with reduction from numbers in excess of 16,000 to 0 was brought about as in 1923 (6) chiefly through the inroads of the ctenophore jelly fish *Mnemiopsis leidyi.* These animals literally swarmed in the water from July 4 till late autumn and through their activities all forms of plankton life were very greatly reduced in numbers (4).

THE VERTICAL DISTRIBUTION OF OYSTER LARVAE

In any study of the abundance of oyster larvae it is of first importance to determine the vertical distribution of the veligers at any given point. Unless this is done comparison of the relative abundance of larvae at one place with that at another has little value. Even where samples are taken close to the bottom and at the surface or at any other uniform depth at the several regions, our experience shows that the vertical distribution of the larvae must be determined before an even approximately true picture of the abundance of the larvae can be secured.

To give a concrete example: At Station 1 (northeast corner Sloop Creek Natural Bed) at 9 a. m., June 9, with strong flood tide 50-liter samples were pumped from depths of 2/0.2, 1.8/0.4, and 1.6/0.6 meters. In these figures the first represents the distance from the surface to the intake of the hose. The second number represents the distance from the intake to the bottom, the sum of the two being the total depth. At the first depth, 0.2 meter (approxiamtely 8 inches) above the bottom, with a temperature of 23.3°C. and a specific gravity of 1.0189, only 54 oyster larvae per 100 liters of water were found, together with a few snail and Teredo larvae. Immediately after this sample was taken, the hose was drawn up 0.2 m., putting the intake 0.4 m. or nearly 16 inches above the bottom, and a second sample of the same size was pumped up. Here in water with a temperature of 23.7°C. and a specific gravity of 1.0165 there were found 12,550 oyster larvae together with swarms of snail larvae. In other words, raising the hose intake a little over half a foot, made all the difference between 54 and 12,550 in the numbers of larvae procured. At 1.6/0.6 meters with a temperature of 23.7°C. and a specific gravity of 1.0144, 9,050 oyster larvae were found. The largest numbers occurred, therefore, in the water of lower specific gravity which lay immediately above the water of higher saline content which was creeping up along the bottom of the bay with the flood tide. The relation between the density of the water and the vertical distribution of the oyster larvae is well illustrated in figure 2, which shows conditions as found at Station 1 during calm weather when absence of wind and wave action permits stratification of the water to take place.

As was explained in the Report for 1925 (5), this reaction of the oyster larva in rising above the area of maximum density results in its being carried farther toward headwateres during the flood than it is carried seaward on the ebb, because of the tendency of the water to mix through wave action or eddies, resulting in relatively little stratification during the ebb tide.

SETTING

As in former years, the time and the intensity of setting were determined by placing two shells in a wire basket at each station, and replacing these by a new pair of shells every 24 hours. The baskets are made like a wallet, holding the oyster shells so that one faces up and the other down when the basket is returned to the bottom. For ease and accuracy in counting, the concave or inner faces of the shells only are used, although frequently the outer surface may bear many spat.

It is of interest to note how much more heavily the inner surface of the shell caught when it was facing downward than when it was facing upward. Of 23 pairs of shells which caught spat at the several stations, those facing upward collected a total of 555 spat, or an average of 24 per shell. The 23 shells which faced downward caught a total of 6,520 spat, an average of 283 spat per shell. A shell thrown overboard in the process of shelling almost invariably falls with the inner surface facing upward, and as a result it soon accumulates a coating of mud. The effectiveness of the more desirable surface of the shell is, therefore, greatly reduced even within 24 hours. Added to this, must be the fact already brought out in our reports for 1925 (4) that the concave face of the shell when downward creates an area of still water protected from light where the larvae find conditions most favorable for setting.

Although it is hardly proposed that the oyster planter place each shell on the bed inner side facing downward, the value of the inner face of the shell could largely be conserved if the shells were planted in windrows rather than being broadly scattered (2).

In figure 1 are given the logarithms of the numbers of spat collected during the preceding 24 hours on the inner surfaces of two shells put down at three stations in Barnegat Bay. It is interesting to note how closely the duration of setting parallels the period during which eyed larvae were found in the plankton collections. This close correlation serves us with an excellent guide to the duration of setting; attachment may be looked for within approximately 24 hours of the appearance of the pallial eye in any considerable proportion of the mature larvae, and cessation of setting is due within approximately the same period after the disappearance of eyed larvae from plankton collections.

THE DEATH OF THE 1925 OYSTER SET

For the first time since beginning our work here in 1921, the oyster growers cooperated with us on a large scale in the planting of shells. In every case the shells were put out just prior to the time of the expected set; the bulk of the shells being overboard by June 13. As a result of this fortunate timing of shelling together with the very large sets which struck June 15 and 21 a heavy catch of spat without doubt the most extensive and valuable set which has occurred since 1921 was secured.

Examination of commercial shells showed, however, that the great majority of spat failed to grow following attachment, the shells becoming snowy white in contrast to the deep reddish purple color of the normal healthy spat. Further examination proved that most of the spat had died within a few hours of attachment without making any new (dissoconch) shell growth. A very few produced shell to approximately the diameter of the larval shell, when they too died. Samples of shells dredged up through July and August showed not over two or three living spat to a bushel of shells out of the thousands of spat which had attached.

In only one small spot in all of the area of upper Barnegat Bay did the spat live in any considerable proportion and this was at the shell loading pier of the Grant estate in Cedar Creek. Through the kindness of Mr. Grant, approximately half a bushel of shells with numerous healthy growing spat were collected at this point and were used by Dr. G. W. Martin in his experiments on feeding.

The cause or causes of the almost universal mortality of the spat over Barnegat Bay are at present unknown. The following possible causes may be ruled out:

1. *Unfavorable salinity of the water.* Examination of figure 1 and comparison with similar figures in the reports for 1924 and 1925 show that there

were no essential departures from normal in the specific gravities obtained during this last year. The living spat taken in Cedar Creek were growing in water of nearly the same specific gravity as that occurring over the large planting grounds at Barnegat Pier where almost universal death of the spat occurred.

2. *Parasites or other enemies.* The oyster drills *Urosalpinx* and *Eupleura,* although abundant off the mouth of Cedar Creek, are absent from the beds lying between Sloop Creek and the mouth of Toms River. Careful search failed to show any sign of holes in the shells of the dead spat, in fact, in most instances the valves were tightly closed, showing that destruction had come from within. Microscopic examination failed to show the presence of parasitic protozoa or other enemies of minute size. The fact that spat brought from Cedar Creek lived well in the very midst of the scene of greatest mortality is further evidence against destruction by enemies.

3. *Smothering by mud or accumulated eel grass.* Wholesale destruction of spat through this cause together with low oxygen content was reported by Churchill and Gutsell (1) as occurring in Great South Bay in 1921. No such cause can be assigned here, since floating eel grass was not present in larger amounts than in former years and much of the shelling was done on hard sandy bottom. An experimental platform raised 7 inches above the bottom at Station 1 caught heavily with spat, but these died as did those on the beds. Tests showed the hydrogen in concentration to be close to pH 7.7, after making correction for the salt error with Cresol Red.

4. *Injury due to high temperatures.* As already explained the high temperature of the first week in June heated the waters of the bay from 18 to 29°C. Although the latter temperature is unusual for Barnegat Bay, the author has found temperatures as high as this and even higher in Huey's Creek, Little Egg Harbor, when excellent sets of oysters occurred. It must be noted also that abnormally high water temperatures did not occur after July 7, and that larvae spawned after that date could have not have been affected except in the egg stage.

One possible explanation is presented. Examination of the oysters during May showed that the eggs were maturing slowly, probably because of the unusually cool weather which occurred during this month. At the time of spawning, the majority of eggs showed relatively large nuclei and incomplete yolk deposition indicating that maturity of the majority of the eggs had not been attained. The sudden burst of extremely hot weather may have caused the oysters to spawn prematurely with consequent weakening of the larvae. It is significant that the mortality of the spat occurred at the two periods in their life when they are most susceptible to unfavorable influences; at the time of attachment, and during rotation with the accompanying adjustment to a fixed habit of life. Should this supposition prove to be correct, the survival of the spat in Cedar Creek may be shown to be due to the more nearly normal maturing of the eggs of the oysters there because of clear shallow water which would permit the passage of a portion of the sun's rays through to the molluscs, thus raising their temperature during the cool weather in May somewhat higher than that of the oysters of the bay. It must be understood, however, that the above is offered not as an explanation, but as the most plausible hypothesis which is presented at this time.

MISCELLANEOUS

The Bayhead-Manasquan Canal

After many years of intermittent digging, the canal from Bayhead to the Manasquan River was opened December 15, 1926. Manasquan Inlet was closed when examination was made of the waters of the canal and at Bayhead on April 2. A strong current was flowing into Barnegat Bay with a speed of approximately 0.3 miles per hour.

The following samples were taken; specific gravity referred to distilled water at 17.5°C.

Johnsons Boatyard, near southern end of canal	1.00368
50 yards downstream from this point	1.00311
At end W. Lake St., Bayhead	1.00292
N. E. corner Barnegat Bay, Bayhead	1.00291
100 yards downstream	1.00301

What conditions would prevail at Bayhead should Manasquan Inlet be kept open cannot be predicted at this time. It is believed, however, that the hopes of some oyster growers that appreciable areas of upper Barnegat Bay would be opened to oyster culture are without foundation. The chief result at this writing of connecting the two bodies of water has been to add the Manasquan River to the tributaries of upper Barnegat Bay.

Solid Fill Across Barnegat Bay

In July a hearing was held in Seaside Park at which the War Department considered the application of the Pennsylvania Railroad to fill in most of the trestle over Barnegat Bay, between Seaside Park and Barnegat Pier. Much opposition to this was voiced by oyster growers and yachtsmen who pointed to Manasquan as an example of the rapid shoaling of the water which follows introduction of solid fill across a tidal estuary. From data based upon the records of our self-registering tide guage, we were able to show that the engineers of the railroad had miscalculated the tidal movements and the amount of water which at times may flow under this bridge. The railroad withdrew its application.

SUMMARY

The feeding of organisms in pure culture to young oyster spat by Dr. G. W. Martin shows that some have a distinctly higher food value than others.

The deficiency in precipitation from 1912 to the end of May, 1926, amounts to some 56.1 inches. Should normal or excess precipitation develop in coming years, the seed-producing areas of Barnegat Bay and the Mullica River, which were largely developed during this period of low rainfall, will be subject to much change.

A continuous recording of the water temperatures of Barnegat Bay correlated with the spawning of the oyster has shown spawning to occur approximately 160 degree hours after the temperature has reached 20°C. (68°F.).

Oyster larvae appeared in numbers by June 4 and began to set July 14, as high as 3,000 spat being found on some test shells down 24 hours.

Further studies of the vertical distribution of oyster larvae show that the veligers are most numerous in the region of less dense water, which lies immediately above the water of highest saline content that creeps up along the bottom of the bay with the flood tide.

The very heavy set on the commercial shells, the most extensive and valuable obtained since 1921 died almost without exception within 24 to 48 hours. The causes of this mortality are at present unknown.

REFERENCES

(1) CHURCHILL, E. P., AND GUTSELL, J. S. "Oyster Investigations for 1921 in Great South Bay, L. I." Mss. U. S. Bureau of Fisheries.

(2) NELSON, T. C. 1921. Aids to Successful Oyster Culture. N. J. Agr. Exp. Sta. Bul. 351.

(3) NELSON, T. C. 1925. Department of Biology. N. J. Agr. Exp. Sta. Ann. Rpt. 1924.

(4) NELSON, T. C. 1925. On the Occurrance and Food Habits of Ctenophores in New Jersey Inland Coastal Waters. Biol. Bull. XLVIII, 92-111.

(5) NELSON, T. C. 1926. Department of Biology. N. J. Agr. Exp. Sta. Ann. Rpt. 1925.

(6) PRYTHERCH, H. S. 1924. Experiments in the Artificial Propagation of Oysters. U. S. Dept. Com., Bur. Fisheries. Doc. 961.

(7) United States Department of Agriculture Weather Bureau. 1925. Climatological Data. New Jersey Section.

Report of the Department of Chemistry

CHARLES S. CATHCART

INTRODUCTORY

The laws of the State of New Jersey regulating the sale of commercial fertilizers, agricultural lime, insecticides, and commercial feeding stuffs prescribe certain work to be performed by the department of chemistry. This work is of sufficient quantity to require practically the entire time of the chemists assigned to the department, and on account of this condition the annual reports for the past years have necessarily been along the same general lines.

During the year ending June 30, 1926, the various inspections have been made and duly reported. In addition to the work required by the inspections, the department has cooperated with the other departments insofar as time would permit. The department was also called upon to establish a branch laboratory in south Jersey for emergency work, caused by the arsenic residue on apples. The detailed report on this work will be given under the section entitled, "Inspection of Insecticides."

ADMINISTRATION

Under the present conditions it is not possible to make the various inspections continuous during the entire year, and, with the exception of the inspection of feeding stuffs, it would not be practicable to do so. It would be very advisable, however, to have the feeding stuffs inspection extended over a longer period than is possible at this time. In order to make the inspections as thorough as possible it is necessary to prepare a time schedule for the various inspections. By following this schedule during the past fiscal year, the various inspections were completed. This was made possible by the faithfulness of each member of the department.

All of the laws regulating these inspections require: (1) an annual registration of the brands to be offered for sale; (2) an annual inspection of the materials found on the markets; and (3) the publication of the results obtained. In addition to these requirements, the fertilizer law and the feeding stuffs law do not permit the lowering of the standard of a brand after it has been once registered and these two laws also require the manufacturers or brokers to render two tonnage reports during the year. The detailed work necessary to take care of the registrations and tonnage reports is quite considerable, but the records are very valuable for immediate and future reference.

The following will show the number of registrations that were made during the year and for which certificates were issued after proper records had been made:

Fertilizer registrations	1381
Lime registrations	89
Insecticides registrations	311
Feeding stuffs registrations	2221
Total number of registrations	4002

During the year a total of 2704 samples were examined and duly reported. The reports on the samples drawn by our inspectors were submitted to the manufacturer responsible for the material and also to the purchaser. The reports on the unofficial samples were forwarded to the party sending the sample.

The results secured during the year were published in Bulletins 422, 424, 426, 431, and 435.

INSPECTION OF COMMERCIAL FERTILIZERS DURING 1925

The complete detailed reports of the 1925 fertilizer inspection were published in Bulletins 413, 422, and 426.

Registrations

The law requires the manufacturers and brokers dealing in fertilizers and fertilizer materials to make an annual registration of the brands they will offer for sale. In accordance with this requirement during the fiscal year ending October 31, 1925, 136 manufacturers and brokers registered 1381 brands of mixed fertilizers and fertilizer materials. The registrations were due on November 1, 1924, and the required publication of the registrations was prepared under date of January 21, 1925, and published as Bulletin 413. The publication of these registrations could not be deferred to a later date if it was to be of any value to the purchaser, but at that date we had received less than two-thirds of the registrations. The registrations that were received after January 21 were tabulated in Bulletin 426.

Reports of Tonnage

The manufacturers or parties responsible for the sale of fertilizers in this state are required to render on April 1 and November 1 of each year a certified report of the tonnage sold during the preceding months. Table 1 shows a summary of the tonnage sold during the last 10 years.

TABLE 1

Summary of Tonnage Reports

Year	April Reports		November Reports		Total for the Year
	Mixed Fertilizers	Fertilizer Materials	Mixed Fertilizers	Fertilizer Materials	
	tons	*tons*	*tons*	*tons*	*tons*
1916	61,368.88	9,032.68	52,328.81	7,069.70	129,800.07
1917	86,840.44	9,146.80	74,231.13	6,264.73	176,483.10
1918	90,371.85	6,544.66	51,404.20	4,877.90	153,198.61
1919	94,463.07	6,264.86	43,594.97	5,162.15	149,485.05
1920	87,942.01	6,452.28	64,847.51	5,379.13	164,820.93
1921	102,834.88	12,851.19	42,501.83	5,298.66	163,486.56
1922	95,929.95	11,550.61	60,362.74	8,580.22	176,423.52
1923	78,137.43	10,963.72	60,085.96	8,309.56	157,496.67
1924	79,011.47	14,092.74	52,284.11	7,438.70	152,827.02
1925	71,745.08	13,989.92	53,385.75	7,566.06	146,686.81

Rules and Regulations

In accordance with the law the state chemist has authority to make rules and regulations relating to the inspection, analysis, and sale of fertilizers. During the past years it has been necessary to make certain rules and regulations which have been published several times. During the year 1925 no special rulings were made.

The ruling which was made effective November 1, 1923, relating to a deficiency in the commercial valuation due to the composition of the material delivered has produced good results. The records for this year show a smaller percentage of deficiencies and, also, a smaller number of shipments that did not have the commercial valuation claimed. This year a total of 106 shipments made by 34 manufacturers had a commercial valuation that was not substantially equal to the valuation of the guaranteed products. These shipments consisted of 71 commercial fertilizers and 35 fertilizer materials. The parties responsible for the products refunded to the purchasers the sum of $1450. For the year 1924 the reports show that 142 shipments made by 42 manufacturers were deficient in the commercial valuation and that the purchasers received a refund of $2200. This condition is an improvement over the one reported last year, since the object of the ruling is to secure for the consumers the plant-food guarantee.

Wholesale Prices of the Essential Elements of Plant-Food for 1925

The wholesale prices of the unmixed or raw materials used in preparing mixed fertilizers are quoted weekly in the trade journal, "The Oil, Paint and Drug Reporter." In order to express the figures given as prices per pound of actual plant-food, which is the form

TABLE 2

Wholesale Cost, Per Pound, in New York, of Essential Fertilizer Elements

Months 1925	NITROGEN IN THE FORM OF					Phosphoric Acid in the form of Acid Phosphate	POTASH IN THE FORM OF			
	Nitrate of Soda	Sulfate of Ammonia	Dried Blood	Ground Fish	Tankage		Muriate of Potash	Sulfate of Potash	Kainit	Manure Salts
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
January	16.56	13.42	21.86	34.30	21.52	2.81	3.42	4.72	3.66	3.14
February	17.01	13.42	21.86	34.30	22.72	2.81	3.42	4.72	3.66	3.14
March	17.04	14.39	21.62	34.30	21.37	2.81	3.42	4.72	3.66	3.14
April	16.84	14.34	22.10	32.12	22.04	2.81	3.42	4.72	3.66	3.14
May	16.69	13.97	22.10	27.93	21.82	2.95	3.42	4.72	3.66	3.17
June	16.18	13.42	21.49	27.63	20.28	3.00	3.42	4.72	3.66	3.17
July	15.77	13.42	23.22	29.75	22.40	3.00	3.42	4.72	3.66	3.17
August	15.76	13.56	23.92	31.57	24.04	3.00	3.42	4.72	3.66	3.17
September	16.02	14.05	24.90	30.36	25.14	3.00	3.45	4.72	3.70	3.30
October	16.28	14.40	24.90	28.60	26.11	3.00	3.46	4.72	3.75	3.34
November	16.53	14.40	24.29	28.11	25.56	3.00	3.46	4.72	3.75	3.34
December	16.79	14.40	24.59	28.84	25.80	3.00	3.46	4.72	3.75	3.34
Average, 1925	16.46	13.93	23.07	30.65	23.23	2.93	3.43	4.72	3.69	3.21
Average, 1924	15.84	13.04	21.07	29.51	19.42	2.46	3.18	4.39	2.93	2.63
Average, 1923	16.02	15.31	25.61	29.98	23.59	2.68	3.30	4.37	2.78	2.51

adopted by the various experiment stations, the quotations given during the year 1925 have been recalculated and are given in table 2.

Station's Trade Values

In order to secure the commercial valuations of the various shipments of fertilizers it is necessary to determine a schedule of valuations for the different elements. This schedule is prepared by tabulating the selling prices as given in the trade papers and by comparing these figures with the price lists which are secured from a number of the manufacturers. From the information secured from these two sources the schedule is prepared for use during the year. The schedule for 1925 was as follows:

	Per unit	*Cents per lb.*
Total nitrogen	$3.64	18.20
Available phosphoric acid........	0.60	3.00
Potash	0.65	3.25

The method for calculating the valuation was to apply the schedule as adopted to the results obtained by the analysis, allowing for the overages as stated in the ruling, and, also, to apply the same schedule to the guarantees as given. If the two values thus secured were substantially equal it was so reported, but if the values did not agree substantially, the valuation of the material examined was divided by the valuation of the guaranteed product and the result represented the percentage of the value which the customer had received.

Inspection

A complete record of an inspection of the fertilizers sold includes:

(*a*) Information regarding the registration and proper branding; (*b*) The collection of the samples; (*c*) The chemical examination; and (*d*) The reports showing the results secured.

Brands Collected

During the inspection our inspectors located 90 different brands which had not been registered at the time of sampling. Some of these brands represented materials in the possession of local manufacturers. Registration of these materials would be unnecessary if they were to be used in registered mixtures and not sold in their original condition. The manufacturers were informed of these omissions as they were found, and they eventually made the registrations. This condition would not have been found if the registrations had been made at the proper time.

Collection of Samples

The law prescribes the method to be used in sampling fertilizers. When the method was adopted it was fully realized that, in order to secure a chemical analysis of a sample that would represent a given shipment, it was very important to secure an accurate sample, because if the sample does not represent the shipment, all of the chemical results are inaccurate and misleading. In full realization of this condition all of the official samples were drawn in accordance with the method outlined in the law and by inspectors who not only appreciate the necessity for careful work but also have had considerable experience with this kind of work.

In order to make the inspection efficient and thorough, itineraries are prepared for the inspectors, who are instructed to sample every brand of material that is located. The success of this part of the work during the past year can be attributed to the faithful and persistent work of the inspectors.

During the past inspection, every county in the state was visited by the inspectors and samples were drawn. A total of 1404 samples were received at the station, a small percentage of which were forwarded by private parties who were not connected with the official inspection work. The samples sent by private parties were examined and duly reported, but the results are not tabulated, since we do not assume the responsibility for the accuracy of the samples. The official samples were taken in duplicate from the stock of 401 dealers and consumers, who were located in 177 cities or towns. The stock of many other dealers and consumers was inspected, but no samples were taken because the same brands had been previously sampled at nearby places.

Official Samples Selected for Examination

The total number of samples that could be collected by our inspectors would be much larger than our present staff of chemists and equipment could work, and, consequently, definite instructions are given as to the number of samples of each brand that should be taken. As a result, every brand located is represented by at least one sample, and a large number of brands by two or more samples.

Every brand received is examined, and if only one sample of a brand has been received there can be no selection for analysis, but when two or more samples of the same brand have been received it is our practice to select the sample which represented the largest tonnage at the time of sampling. Frequently a purchaser makes a special request for the analysis of his goods and in such cases the analyses are made and tabulated in the proper places.

The samples analyzed during the present year consisted of the following:

Commercial fertilizers (Nitrogen, Phosphoric Acid, and Potash)	426
Commercial fertilizers (Nitrogen and Phosphoric Acid)	6
Commercial fertilizers (Phosphoric Acid and Potash)	3
Commercial fertilizers (Duplicates)	192
Home mixtures	22
Humus and manures	14
Fertilizer materials	239
Ground Bone	37
Sundry materials	190
Total	1129

Average Guarantees and Actual Composition

The total number of samples of mixed fertilizers examined was 627, representing 435 different brands. There were 426 brands guaranteed to contain nitrogen, phosphoric acid, and potash; 6 brands guaranteed to contain nitrogen and phosphoric acid; and 3 brands guaranteed to contain phosphoric acid and potash.

TABLE 3

Average of 426 Brands Containing Nitrogen, Phosphoric Acid, and Potash

Average Selling Price, per ton, $37.84

	AVERAGE		
	Found	Found	Guaranteed
	per cent	*per cent*	*per cent*
Nitrogen, as nitrates	0.45		
Nitrogen, as ammonia salts	1.46		
Nitrogen, as water-soluble organic	0.47		
Nitrogen, as water-insoluble organic	0.56		
Nitrogen, total		2.94	2.97
Phosphoric Acid, total	9.70		
Phosphoric Acid, insoluble	1.29		
Phosphoric Acid, available		8.41	8.29
Potash		5.77	5.60

Table 3 shows that the average guarantees in the brands containing nitrogen, phosphoric acid, and potash were satisfied.

Average Composition of Commercial Fertilizers

In order to compare the results obtained with the fertilizers containing nitrogen, phosphoric acid, and potash with the results obtained with similar brands during the preceding nine years, table 4 has been prepared.

TABLE 4

Average Composition of Fertilizers for Ten Years

Year	Total Nitrogen	Total Phosphoric Acid	Insoluble Phosphoric Acid	Insoluble Phosphoric Acid	Potash	Selling Price
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	
1916	2.39	10.67	8.98	1.69	1.39	$32.43
1917	2.63	10.51	8.73	1.78	1.83	34.35
1918	2.31	10.19	8.53	1.66	1.96	46.72
1919	2.10	10.03	8.58	1.45	2.24	58.73
1920	2.35	9.80	8.38	1.42	3.86	53.10
1921	2.46	9.83	8.49	1.34	4.26	54.10
1922	2.68	9.74	8.54	1.20	5.13	38.24
1923	2.71	9.49	8.28	1.21	5.48	35.69
1924	2.97	9.44	8.18	1.26	5.75	36.00
1925	2.94	9.70	8.41	1.29	5.77	37.84

Deficiencies

A study of the detailed results of the mixed fertilizers as published in the bulletins will show that 66 brands fully satisfied all of the guarantees given and that 250 other brands substantially satisfied the guarantees. Three samples were special mixtures without guarantees. There were 116 brands, or about 27 per cent, deficient.

Last year 35 per cent of the brands were deficient, which shows a slight improvement.

Table 5 shows the deficiencies as reported during the past ten years. In preparing this tabulation, deficiencies of 0.2 per cent or less of nitrogen, or 0.3 per cent of phosphoric acid or potash have been disregarded.

TABLE 5

Comparison of Deficiencies From 1916 *to* 1925

	RECORD OF BRANDS					ACTUAL DEFICIENCIES			
Year	Number Examined	No. Found as Guaranteed	Number Found Deficient	Deficient	Deficiencies Possible	Nitrogen	Phosphoric Acid	Potash	Found
				pc.					*pc.*
1916	565	356	209	37	1,406	139	81	17	16.9
1917	552	380	172	31	1,360	85	88	15	13.8
1918	502	352	150	30	1,218	82	69	15	13.6
1919	556	388	168	30	1,396	98	73	17	13.5
1920	512	340	172	33	1,390	104	61	31	14.0
1921	516	342	174	34	1,462	89	65	43	13.5
1922	526	321	205	39	1,528	123	56	52	15.1
1923	475	322	153	32	1,398	49	85	42	12.7
1924	463	299	164	35	1,369	52	92	40	13.4
1925	435	316	116	27	1,287	47	60	20	10.0

There were 1287 deficiencies possible in the brands examined this year, and of this number 127, or 10 per cent, were found; these deficiencies, consisting of nitrogen 47, phosphoric acid 60, and potash 20, were distributed in 116 brands, 105 being deficient in one element and 11 in two elements. During the preceding ten years the percentage of deficiencies ranged from 12.7 to 16.9.

Character of the Nitrogen Content in Mixed Fertilizers

The law requires a guarantee for the content of total nitrogen, but it is well known that this element can be derived from many sources, some of which are valuable for plant growth, whereas other sources are in an inactive form.

In order to get additional information regarding the character of the nitrogen delivered, every brand of mixed fertilizer is examined for its content of nitrogen derived from nitrate of soda, from sulfate of ammonia, and from organic matter. In addition, the amount of water-soluble organic nitrogen is determined, and also the activity of the insoluble portion. With these detailed results the value of the total nitrogen content can be determined more accurately.

All of the mixed fertilizers guaranteed to contain nitrogen derived a portion of this element from an organic source, although a few brands contained but a small amount in this form. During the past few years, on the average, the different brands contained about one-third of their total nitrogen, or 1 per cent, as organic nitrogen. Since the quantity of organic nitrogen is somewhat limited, and also the most expensive form of this element, very careful attention should be given to the character of this form of nitrogen. During the inspection, the activity of the insoluble nitrogen was determined in all samples containing 0.3 per cent or more of insoluble nitrogen, and the results show that 46, or 11 per cent, of the brands contained an inferior grade of nitrogen. Twenty-five of these brands contained more total nitrogen than was guaranteed, this excess being sufficient in 8 brands to offset the amount of inferior quality and in 15 brands partially to offset the amount present in this form. This is practically the same result as reported last year.

The water-soluble forms of nitrogen furnished two-thirds of the total nitrogen content in the mixed fertilizers. The records show that 243 brands, or 57 per cent, contained nitrogen derived from nitrate salts; 412 brands, or nearly 97 per cent, contained ammonia salts, and 226 brands, or 53 per cent, contained both of these water-soluble forms.

Grades of Commercial Fertilizers Sold

During the inspection, commercial fertilizers with 96 different guarantees which varied from 1-7-1 to 10-5-5 were collected. It is quite evident that this large variety was sufficient to supply the needs and the special ideas of the consumers in this state. The most popular brands were confined to the 4 distinct groups; 1-8-2 to 1-8-4, 2-8-2 to 2-8-10, 4-8-4 to 4-8-10, and 5-8-4 to 5-8-7. These four groups furnished 66 per cent of the brands collected.

Special effort is being made to foster the use of high analysis fertilizers. It is very gratifying, therefore, to find that the New Jersey farmer has followed this practice for a number of years, since, according to a tabulation in Bulletin 368, for the years 1888 to 1921, omitting the period 1916-1919, from 58 to 80 per cent of the brands were high analysis mixtures, and this year 85 per cent of the brands were in this class, 12 per cent were medium analysis and only 3 per cent were of low analysis.

Cost of Plant-Food in Commercial Fertilizers

The price charged for a fertilizer depends upon the number of pounds of plant-food contained in the mixture, together with the charge for mixing, bags, freight, selling charges, and profit. The charge for mixing and bags is the same for all grades of mixtures, whereas the cost of freight and cartage will depend upon the amount purchased. It should be quite clear that the plant-food in the lower grades of mixtures costs more than if obtained in the high-grade mixtures. Although the New Jersey record shows in favor of the high-grade mixtures, still some improvement can be made by eliminating the comparatively few low-grade brands.

It should be considered quite necessary to know the cost of the plant-food desired. This information can be secured without much trouble by following the procedure given. The sum of the guarantees for nitrogen, phosphoric acid, and potash in a given fertilizer will give the number of pounds of plant-food in 100 pounds of the mixture, and if this sum is multiplied by 20 the final result will be the number of pounds of plant-food in a ton of the fertilizer. Having secured this figure, if the retail price per ton is divided by it, the result will be the cost of each pound of plant-food.

If this simple method of calculation is followed when the purchase of fertilizers is considered, and if the comparisons are made, the purchaser will be able to secure greater value for the money expended.

Table 6 has been prepared in order to show the average cost per pound of plant-food during the past four years.

TABLE 6

Cost of Plant-Food Per Pound

Year	Average Retail Cost of Fertilizer for Each Ton	Amount of Plant-Food in One Ton	Average Retail Cost of One Pound of Plant-Food
		pounds	*cents*
1922	$38.25	327.0	11.7
1923	35.69	329.4	10.8
1924	36.00	338.0	10.7
1925	37.84	342.4	11.0

Ground Bone

During the inspection 37 samples of ground bone were examined, the results of which are tabulated on subseqeunt pages. Table 7 gives the average composition and selling price for the past ten years.

TABLE 7

Average Composition of Ground Bone

Year	Fine Bone	Coarse Bone	Nitrogen	Phos-phoric Acid	Selling Price
1916	53.0	47.0	2.80	23.80	$39.50
1917	58.0	42.0	2.95	24.28	38.82
1918	59.0	41.0	2.85	24.84	48.49
1919	58.0	42.0	2.93	24.82	54.71
1920	58.0	42.0	2.97	25.06	54.23
1921	53.0	47.0	3.12	24.40	54.80
1922	51.5	48.5	3.17	24.11	42.16
1923	49.0	51.0	3.21	23.87	49.00
1924	52.0	48.0	3.53	23.11	42.67
1925	45.0	55.0	3.43	23.24	45.13

Summary of the Results Obtained with Mixed Fertilizers Examined During the Inspection of 1925

Manufacturer	Address	Number of Brands Received	Number of Samples Examined	Number of Samples Satisfied Guarantees	Number of Samples Substantially Satisfied Guarantees	Number of Samples Equal in Commercial Value to Guarantee	Number of Samples Deficient in					
							Nitrogen	Phosphoric Acid	Potash	One Element	Two Elements	Three Elements
Acme Guano Co.	Baltimore, Md.	8	14	....	4	6	....	10	1	9	1	....
American Agricultural Chemical Co.	New York City	44	64	16	45	64	1	2	....	3	....	....
American Fertilizing Co.	Baltimore, Md.	1	1	....	....	....	....	1	....	1	....	....
Armour Fertilizer Works	New York City and Carteret, N. J.	15	23	1	16	20	4	2	....	6	....	....
Baugh & Sons Co.	Philadelphia, Pa.	18	30	1	23	25	3	3	....	6	....	....
G. A. Bennett	Hightstown, N. J.	2	2	....	2	2	....	....	....	....	....	....
Berger Fertilizer & Chemical Co.	Philadelphia, Pa.	2	2	....	2	2	....	....	....	....	....	....
Bowker Fertilizer Co.	New York City	13	18	6	12	12	....	....	....	....	....	....
W. M. Brown & Son	Cedarville, N. J.	1	2	....	2	2	....	....	....	....	....	....
Chamberlin & Barclay	Cranbury, N. J.	*3	4	....	....	3	....	....	3	3	....	....
Coe-Mortimer Co.	New York City	10	15	3	12	15	....	....	....	....	....	....
J. S. Collins & Son, Inc.	Moorestown, N. J.	3	4	....	3	4	....	1	....	1	....	....
Consumers' Chemical Corporation	New York City	1	1	....	....	1	....	1	....	1	....	....
Co-operative G. L. F. Exchange, Inc.	New York City	15	25	2	10	21	5	7	1	13	....	....
Co-operative Growers' Association	Beverly, N. J.	3	5	1	....	5	2	3	....	3	....	....
Dumont Fertilizer Co., Inc.	Philadelphia, Pa.	17	28	2	12	19	10	3	4	12	1	1
Farmers' Co-operative Association of Cape May	Rio Grande, N. J.	1	2	....	....	1	2	....	1	1	1	....
Farmers' Co-operative Association of Mercer County	Trenton, N. J.	1	1	1	....	1	....	....	....	....	....	....
Farm Service Exchange	Morristown, N. J.	1	1	1	....	1	....	....	....	....	....	....
Fogg & Hires Co.	Salem, N. J.	1	2	....	....	1	....	....	1	1	....	....
Godfrey Fertilizer & Chemical Co.	Newark, N. J.	5	7	....	3	4	....	2	2	4	....	....
Hendrickson & Dilatush	Robbinsville, N. J.	2	3	3	....	3	....	....	....	....	....	....
Heritage & Bro.	Mullica Hill, N. J.	5	9	....	9	9	....	....	....	....	....	....
S. M. Hess & Bro., Inc.	New York City	8	13	4	9	13	....	....	....	....	....	....
Hill Bros.	Flemington, N. J.	1	1	....	1	1	....	....	....	....	....	....
Hubbard Fertilizer Co.	Baltimore, Md.	2	2	....	1	2	....	1	....	1	....	....
Hunterdon County Farmers' Co-operative Association	Flemington, N. J.	5	5	....	4	5	1	....	....	1	....	....
Independent Manufacturing Co.	Philadelphia, Pa.	3	3	2	1	3	....	....	....	....	....	....

*One special mixture.

International Seed Co.	Rochester, N. Y.	3	3	2	....	3	....	1	....	1	....	....
M. Kauffman	Bridgeton, N. J.	1	1	1	....	1	....	....	....	....	....	....
H. B. Kemp	Long Branch, N. J.	6	6	....	3	6	1	2	....	3	....	....
Keystone Bone Fertilizer Co.	Philadelphia, Pa.	6	6	3	1	5	1	....	1	2	....	....
King Chemical Co.	Bound Brook, N. J.	3	3	....	....	2	1	3	....	2	1	....
S. Lederer & Son	New Brunswick, N. J.	1	1	....	....	1	1	1	....	....	1	....
F. Leonelli	Landisville, N. J.	3	3	....	3	3	....	....	....	....	....	....
Mapes F. & P. Guano Co.	New York City	8	12	9	3	12	....	....	....	....	....	....
Miller Fertilizer Co.	Baltimore, Md.	3	3	....	1	2	1	1	....	2	....	....
Monmouth County Farmers' Exchange	Freehold, N. J.	5	11	4	7	11	....	....	....	....	....	....
J. R. Moore & Son	Swedesboro, N. J.	7	11	2	8	11	1	....	....	1	....	....
A. Nelson	Allentown, N. J.	3	3	....	1	2	2	....	....	2	....	....
New Jersey Fertilizer & Chemical Co.	New York City	1	1	....	....	1	1	....	....	1	....	....
C. Peckart & Son	Paterson, N. J.	1	1	....	1	1	....	....	....	....	....	....
Peerless Fertilizer Co.	Chestertown, Md.	7	10	....	2	6	6	3	....	7	1	....
Pennsylvania Guano Co.	Philadelphia, Pa.	3	3	2	1	3	....	....	....	....	....	....
Philadelphia Guano Works	Philadelphia, Pa.	5	6	2	2	5	....	....	2	2	....	....
Piedmont-Mt. Airy Guano Co.	Baltimore, Md.	2	3	....	2	2	....	1	1	....	1	....
Rasin-Monumental Co.	Baltimore, Md.	10	16	1	10	15	....	4	2	4	1	....
Reed & Perrine	Tennent, N. J.	1	2	....	2	2	....	....	....	....	....	....
R. A. Reichard, Inc.	Allentown, Pa.	4	4	....	2	3	....	2	....	2	....	....
Rooney & Ely Co.	Englishtown, N. J.	1	3	1	2	3	....	....	....	....	....	....
F. S. Royster Guano Co.	Baltimore, Md.	13	19	....	11	15	4	5	....	7	1	....
Chas. E. Rue	Windsor, N. J.	1	1	....	1	1	....	....	....	....	....	....
Schanck & Field, Inc.	Hightstown, N. J.	1	1	....	1	1	....	....	....	....	....	....
Scott Fertilizer Co.	Elkton, Md.	3	3	....	1	3	....	....	2	2	....	....
J. C. Shoemaker	Bridgeton, N. J.	2	2	....	....	2	....	....	2	2	....	....
M. L. Shoemaker & Co., Inc.	Philadelphia, Pa.	7	8	4	2	8	1	1	....	2	....	....
South Jersey Farmers' Exchange	Woodstown, N. J.	6	10	1	7	10	1	1	....	2	....	....
Star Fish & Bone Fertilizer Co., Inc.	Bridgeton, N. J.	‡7	12	4	2	10	2	2	....	4	....	....
Summers' Fertilizer Co., Inc.	Baltimore, Md.	16	19	....	10	14	3	4	2	9	....	....
Superior Guano Co.	Baltimore, Md.	1	1	....	....	....	....	....	1	1	....	....
Swedesboro Supply Co.	Swedesboro, N. J.	4	6	....	3	6	....	3	....	3	....	....
Swift & Co.	Baltimore, Md.	19	28	1	23	25	2	3	....	3	1	....
I. P. Thomas & Son Co.	Philadelphia, Pa.	15	22	2	16	20	2	2	1	3	1	....
Trenton Bone Fertilizer Co.	Trenton, N. J.	18	24	8	13	22	2	1	....	3	....	....
F. W. Tunnell & Co., Inc.	Philadelphia, Pa.	13	24	6	10	20	1	5	2	8	....	....
U. S. Guano Co.	Baltimore, Md.	4	4	2	....	2	1	2	....	1	1	....
Virginia Carolina Chemical Co.	New York City	17	24	2	15	21	1	6	1	6	1	....
West Jersey Marl & Transportation Co.	Woodbury, N. J.	9	15	1	11	15	2	1	....	3	....	....
W. Wilde	Vineland, N. J.	2	3	3	....	3	....	....	....	....	....	....
J. R. Wyckoff	Princeton Junction, N. J.	2	2	1	1	2	....	....	....	....	....	....

‡Two special mixtures.

INSPECTION OF AGRICULTURAL LIME DURING 1925

During the year, 44 manufacturers registered 89 different brands of agricultural lime.

Inspection

A comparatively large number of samples of the various lime products were examined and duly reported during the year. Many of the samples were forwarded by individuals for analysis and the reports were made, but were not published, since we had no official information regarding the sampling. The results of the official samples were published in Bulletin 426.

INSPECTION OF INSECTICIDES AND FUNGICIDES DURING 1925

The detailed results of this inspection were published in Bulletin 424.

Inspection

The inspection of the branding and the collection of the official samples reported in this bulletin were made by F. S. Beckwith, B.Sc. By visiting the different sections of the state where these materials are used in large quantities, 124 official samples were secured. In addition to the official samples, 18 samples were forwarded by individuals.

The total number of samples examined was 138. All of the results, with the exception of those obtained with the unofficial samples, were tabulated in Bulletin 424. As soon as the work had been completed the results of the unofficial samples were sent direct to the parties submitting the samples.

The official samples examined were accompanied by 206 guarantees. The results obtained show that 16 of these guarantees, or 7.8 per cent, were not sustained.

The samples examined consisted of the following:

13 samples of paris green
17 samples of lead arsenate powder
3 samples of lead arsenate paste
11 samples of calcium arsenate
9 samples of bordeaux mixture
1 sample of atomic sulfur
9 samples of sulfur mixtures
3 samples of lime-sulfur solution
1 sample of sulfocide
8 samples of soluble-sulfur compounds
11 samples of nicotine preparations
34 samples of miscellaneous brands
18 unofficial samples

138 Total

Arsenic Residue on Apples

The apple growers of south Jersey were very much disturbed, during the latter part of the year 1925, by certain reports from the United States Department of Agriculture showing that some of the shipments of apples carried an excessive quantity of arsenic residue.

On account of these reports, the growers did not want to assume the moral or legal responsibility for making shipments in the condition reported, but it was quite imperative to sell the stock on hand, which was estimated at 400,000 bushels. The question was thoroughly discussed at a conference, at which time it was decided to have the entire stock examined and cleaned when necessary. The State Board of Agriculture agreed to furnish two inspectors to go over the stock and to take samples, which would be examined by chemists supplied by the Experiment Station.

In order that the work might be done with as little delay as possible, it was decided to establish a temporary laboratory in the district affected and permission was received to use one of the rooms at the State Normal School, Glassboro, N. J., as a laboratory for this purpose. Inasmuch as the work to be done was of a special character, it was necessary to purchase the equipment before the work could be started. The apparatus and materials needed were purchased and in one week from the time of securing the room, the chemists were ready to make the analyses.

There were two problems connected with this work; viz., sampling and chemical analysis, the most difficult and laborious one being the sampling. The method adopted for the sampling was as follows: the inspectors to select about one bushel of apples from a definite lot which had the appearance of having the largest amount of arsenic residue; this sample was passed to the chemists who selected the worst specimens from the lot delivered and determined the quantity of arsenic present. By this method of sampling, it was felt that if the apples actually anaylzed, passed the requirements, there could be no question in regard to the lot represented by the sample. If the sample did not pass the requirements, the whole lot was sent to a brushing machine and a sample taken after the brushing, in the same manner as noted above. If the brushing machine did not remove the residue, the lot was put through a washing machine.

The inspectors secured 156 samples and 10 samples were submitted by individuals. This work permitted the growers to dispose of their stock with a confident feeling that the apples would be in a good condition.

Under the usual conditions the work of the chemical department is sufficient to require the entire time of the staff assigned to the work, consequently some rearrangements were necessary in order to do our regular work and also to supply two chemists for the branch laboratory. Dr. H. C. McLean, of the soil laboratory, and L. R. Smith, of this laboratory, were selected for the special work, and it is largely due to their efforts that the work was completed in such a satisfactory manner.

INSPECTION OF COMMERCIAL FEEDING STUFFS DURING 1925

The detailed results of the inspection of commercial feeding stuffs were published in Bulletin 435.

The New Jersey Feed Law

The purpose of the law is to require each feeding stuff sold in the state to be accompanied by definite statements as to its content of the different nutrients, and also the specific names of the materials in the product. It is quite evident that such statements are a protection to the honest manufacturer and to the consumer provided sufficient attention is given to the statements made. There is no doubt that the larger manufacturers understand and make use of the information given in the guarantees, but, judging by many experiences, many of the smaller local manufacturers and many of the consumers do not obtain the full benefits because they do not give the proper attention to the statements given.

In order to secure the maximum benefits of the law it is necessary to be familiar with the requirements as specified and to use this information when selecting a purchase. The law requires a statement of the minimum guarantees of crude protein and crude fat and the maximum guarantee for crude fiber, and this information together with the selling price should be sufficient for an intelligent purchase of an unmixed feed. If the feeding stuff is a mixture, in addition to the information as stated above, a careful examination of the names of the ingredients used in the mixture should be made. With the exception of the selling price, the law requires this information to be attached to all feeding stuffs with but a few exceptions. The feeds which are not required to be guaranteed are whole seed or grain sold as such and the unmixed feeds made from and consisting of the entire grains of corn, wheat, rye, barley, oats, buckwheat, flaxseed, kafir and milo; neither shall it include whole hays, straws, cottonseed hulls, and corn stover when unmixed with other materials, nor shall it include wet brewers' grain. A shipment of any feeding stuff, other than those enumerated above, which is not accompanied by a guarantee, does not conform to the law and should not be purchased, or if it has been ordered and delivered without the guarantees, the material should not be accepted until the guarantees have been supplied.

The state chemist's department makes regular inspections of the feeding stuffs on the market, but it is possible that the inspectors do not locate every shipment made, and consequently, if a shipment has been received that is not properly guaranteed, the condition should be reported in order that an investigation may be made and the party responsible for the material required to furnish the full information.

Registrations

During the year 1925, 473 manufacturers and brokers registered 2,221 brands which they would offer for sale in this state. The law requires these registrations to be made on January 1 of each year, but many of the registrations made were not received until our inspectors had located the shipments and had stopped the sale of the material. This condition was not confined to any one class of manufacturers, but the largest number of omissions was caused by the small manufacturers who do a local business only. There is no legimate reason for this condition and the manufacturers should realize that it is to their interest to attend to this requirement at the proper time.

Tonnage of Feeding Stuffs Sold

Manufacturers and those responsible for feeding stuffs sold in this state are required to render reports on July 1 and January 1 of each year, showing the total tonnage sold during the six months preceding these dates. These reports do not show the tonnage of each brand of material, but simply show the total tonnage. Table 8 is a summary of the reports received during the past ten years.

TABLE 8
Summary of Tonnage Reports

Year	July Reports	January Reports	Total for Year
1916	111,910.84	123,437.16	235,348.00
1917	114,939.37	119,101.06	234,040.43
1918	108,771.45	121,635.23	230,406.67
1919	102,837.34	144,052.15	246,889.49
1920	120,156.78	135,897.75	256,054.53
1921	123,752.97	154,187.88	277,940.85
1922	134,876.65	159,965.17	294,841.82
1923	140,470.08	182,934.01	323,404.09
1924	153,889.40	167,551.96	321,441.36
1925	149,365.93	163,833.81	313,199.74

Inspection

In order to make the inspection as thorough as possible, the inspectors were supplied with carefully prepared itineraries, which included every county in the state. These itineraries were followed quite closely and as a result 1,816 official samples were secured from the stock of 299 dealers and consumers who were located in 186 different cities or towns. The stock of many other dealers and consumers were examined as to the branding, but were not sampled because the same brands had been sampled at nearby places.

In addition to the 1,816 official samples collected, 230 samples were forwarded by individuals with a request for analysis.

Results of the Examinations

Every brand collected by our inspectors is subjected to a microscropical and chemical examination. The results secured were duly reported to the manufacturer and to the party having the stock from which the sample was taken. If the sample satisfied the guarantee given, the two reports were issued at the same time, but if the sample was deficient, the report was submitted to the manufacturer and he was allowed ten days to check the report if he so desired. At the expiration of the ten days the report was made official and submitted to the purchaser.

There were 1196 official samples examined and the results are tabulated in bulletin 435. These samples include 3 which were taken by special request of the purchaser but on account of their source did not require guarantees to be attached. Forty-five brands were represented by official samples which at the time of sampling did not show the required guarantees and the parties having these feeds were notified not to sell the same until the information had been attached. Thirty of the 45 unguaranteed samples represented feeds being sold by local manufacturers and the total tonnage was very small; 4 samples represented shipments by brokers; and 11 samples were products sold by manufacturers. Practically all of these samples were registered but the published records do not show the guarantees because they were not attached at the time of taking the sample.

The results of the examination of the 1,148 guaranteed samples show that 503 fully satisfied the guarantees given for the minimum content of crude protein and crude fat and the maximum content of crude fiber; and in addition, 310 samples substantially satisfied these guarantees. There were 335, or 29.2 per cent of the samples deficient—286, or 25 per cent, were deficient in one nutrient; 46, or 4 per cent, were deficient in two nutrients; and 3, or 0.2 per cent, were deficient in the three nutrients. The deficiency in the nutrients consisted of the following: protein 110; fat 96; fiber 181.

All of the unofficial samples were examined and reports made to the parties sending the samples, but the results are not included in this report.

A comparison of the number of deficiencies found during the last ten inspections is given in table 9, which shows that the character of the feeding stuffs sold during the past year was very much poorer than it has been since 1918.

TABLE 9

Summary of Deficiencies

	Samples Examined	Samples Deficient	Samples Deficient in		
			Protein	Fat	Fiber
		per cent	*per cent*	*per cent*	*per cent*
1917	1103	32.3	10.0	9.3	10.6
1918	932	27.9	9.3	8.9	16.2
1919	810	22.1	9.6	4.6	12.0
1920	822	20.8	8.0	7.2	9.5
1921	863	15.4	7.9	7.0	3.3
1922	927	18.9	9.5	7.2	5.7
1923	948	12.6	6.0	7.2	1.3
1924	975	21.2	7.7	7.4	9.9
1925	1030	21.0	7.2	6.5	10.2
1926	1148	29.2	9.6	8.4	15.8

It is hardly possible to give a satisfactory explanation for this deplorable condition, since the manufacturers claim that they are using the utmost care in the preparation of their feeds, but the fact remains that the shipments were sampled and the reports as tabulated in the bulletin were submitted to them, and, with a few exceptions, no question was raised regarding the reports. This would lead one to think that most of the manufacturers who were responsible for the deficient shipments were satisfied with the results secured.

The records show that there were 358 brands of feed mixtures prepared by the local manufacturers whose total sales, if we do not include the larger manufacturers, is small, and of this number 135, or 37.7 per cent, were deficient. There were 7.8 per cent deficient in protein; 12.3 per cent deficient in fat, and 25.1 per cent deficient in crude fiber. If we deduct these figures from the totals as noted previously, there were 790 brands manufactured out of the state, and 200 of this number were deficient; 10.4 per cent were deficient in protein; 6.6 per cent deficient in fat; and 11.5 per cent deficient in fiber. It will be noted that the local manufacturers' brands carried a smaller percentage of deficiencies in protein and much larger percentage of deficiencies in fat and fiber than the other brands.

Many of the deficiencies in the brands of the local manufacturers were due to improper mixing and to the statement of guarantees which could not be obtained from the materials used.

Summary of the Inspection

Table 10 gives a summary of the inspections for 1925. This table does not show the averages for the various kinds of mixed feed because of the variable composition of the individual brands. In securing the results tabulated under the heading "number of samples substantially satisfied guarantees," it was considered that a sample was in this class if it was not more than 1 per cent low in protein, 0.5 per cent low in fat, or 0.5 per cent high in fiber.

With but few exceptions the average selling prices are given. These figures were obtained by making an average of the prices given to the inspectors at the time the sample was taken. In a few instances we were unable to secure these prices, which will account for our records not being complete.

TABLE 10

Summary of the Results of the Inspection

	Number of Samples Examined	Average Composition				Average retail selling price per ton	Number of samples satisfied guarantees	Number of samples substantially satisfied guarantees	Number of Samples Deficient in					
		Water	Protein	Fat	Fiber				Protein	Fat	Fiber	One Nutrient	Two Nutrients	Three Nutrients
		percent	*percent*	*percent*	*percent*									
Alfalfa Meal	12	8.71	14.43	1.84	27.96	$49.60	9	3	....	....	....	....	....	....
Bone Meal	3	6.55	25.37	1.55	*24.48	72.60	2	....	....	1	....	1	....	....
Brewers' Dried Grains	^{2}22	7.03	21.84	7.20	15.45	44.00	9	1	5	1	7	7	3	....
Brewery Products	4	4.89	16.49	3.31	11.72	....	4	....	....	....	....	....	....	....
Buckwheat Feed	^{1}2	9.23	23.38	5.77	2.56	45.00	....	....	1	1	....	....	1	....
Buckwheat Middlings	^{2}7	12.55	31.05	8.03	4.77	38.40	5	....	....	....	....	....	....	....
Buckwheat Offal	^{1}5	8.13	15.95	4.12	23.65	30.80	....	....	....	....	4	4	....	....
Buckwheat Hulls	^{1}1	5.50	4.44	0.97	39.60	12.00	....	....	....	....	....	....	....	....
Buckwheat Screenings	1	12.37	12.13	3.17	5.74	44.00	....	1	....	....	....	....	....	....
Calf Meal	6	....	....	....	....	93.80	2	2	....	2	....	2	....	....
Corn Bran	1	8.57	10.13	3.10	9.00	33.00	....	....	....	1	....	1	....	....
Corn and Cob Meal	8	11.37	7.14	3.35	7.16	33.80	1	1	2	....	4	6	....	....
Corn and Oats	^{3}18	11.06	10.13	4.54	6.36	46.20	7	2	....	1	5	6	....	....
Corn Distillers' Dried Grains	2	6.78	23.85	6.80	13.71	47.00	....	1	1	....	....	1	....	....
Corn Feed Meal	^{2}15	11.58	8.90	4.24	3.03	46.20	6	3	1	1	2	4	....	....
Corn Gluten Feed	18	9.59	24.26	2.29	7.94	50.70	11	5	1	....	1	2	....	....
Corn Gluten Meal	3	8.20	41.86	1.59	2.74	59.60	2	....	1	....	....	1	....	....
Cottonseed Meal	^{2}26	6.75	40.71	7.08	9.89	54.80	9	9	5	....	3	4	2	....
Dried Beet Pulp	8	8.65	8.33	0.67	20.52	48.80	1	3	....	....	4	4	....	....
Dried Malt Grains	2	5.01	21.63	6.58	14.34	44.00	2	....	....	....	....	....	....	....
Feed Mixtures	^{2}180	....	....	....	....	48.80	76	46	18	15	35	44	12	....
Feed Mixtures, N. J. Manufacturers	^{3}113	....	....	....	....	47.40	40	26	8	11	34	35	9	....
Fish Meal	3	5.56	53.67	6.08	*9.90	97.00	3	....	....	....	....	....	....	....
Flaxseed Screenings	^{1}3	9.24	12.23	8.17	18.34	35.00	1	....	....	1	....	1	....	....
Hominy Feed	22	9.23	10.10	6.06	4.54	44.40	8	8	....	6	....	6	....	....
Linseed Oil Meal	15	9.01	33.83	6.56	8.29	57.00	6	8	....	1	....	1	....	....
Milk Products:														
Dried Milk Albumen	1	6.00	29.75	....	†45.45	124.00	....	....	1	....	....	1	....	....

Dried Buttermilk	[2]8	9.49	30.95	....	†11.77	174.00	2	2	2	....	....	2	....	....
Condensed Buttermilk	1	69.56	11.06	....	†5.03	82.00	1	....	....	....	....	....	....	....
Oats, Ground	[2]2	9.27	11.63	4.98	11.35	....	....	....	....	....	....	....	....	....
Oat Feed	8	7.06	7.46	2.93	26.48	33.20	2	4	....	....	2	2	....	....
Oat Groats	1	6.85	15.56	6.80	1.27	89.00	....	1	....	....	....	....	....	....
Oat Meal	[1]5	7.82	15.15	6.59	2.32	69.20	2	1	1	....	....	1	....	....
Oat Middlings	1	7.18	16.38	7.34	8.39	....	....	....	....	....	1	1	....	....
Oats, Rolled	[3]4	8.50	14.96	7.20	1.12	77.40	....	1	....	....	....	....	....	....
Poultry Feed	[1]204	....	....	....	....	63.80	103	76	9	12	7	21	2	1
Poultry Feed, N. J. Manufacturers	[4]262	....	....	....	....	58.00	96	60	20	33	56	75	14	2
Poultry Meat	[1]49	5.31	48.44	12.15	*10.86	73.40	13	10	25	1	....	24	1	....
Rye Bran	3	12.25	14.63	2.85	4.98	31.60	....	2	....	....	1	1	....	....
Rye Feed	1	9.81	16.06	3.39	4.08	....	1	....	....	....	....	....	....	....
Rye Middlings	5	10.77	14.20	3.10	3.86	35.60	4	1	....	....	....	....	....	....
Tankage, digester	4	7.20	58.54	9.07	*7.50	76.00	....	1	2	1	....	3	....	....
Wafer Meal	1	7.10	10.00	6.04	0.55	....	....	....	1	....	....	1	....	....
Wheat Bran	[1]52	9.99	14.63	4.84	9.95	38.80	27	13	2	3	6	11	....	....
Wheat Feed	10	9.75	15.61	5.35	7.40	43.20	7	....	1	....	2	3	....	....
Wheat Feeding Flour	13	9.92	15.81	3.82	2.10	46.76	5	4	2	3	....	3	1	....
Wheat Middlings	[2]60	10.00	16.07	5.06	5.54	45.68	35	15	1	1	7	7	1	....
Wheat and Rye White Middlings	1	9.91	14.63	4.48	4.29	42.00	1	....	....	....	....	....	....	....

---

*Total phosphoric acid.

†Ash.

[1] One sample not guaranteed.

[2] Two samples not guaranteed.

[3] Three samples not guaranteed.

[4] Fifteen samples not guaranteed.

Report of the Department of Dairy Husbandry

John W. Bartlett

EXPERIMENTAL

During the years 1925-26, eleven different research problems relating to the field of dairy husbandry have been under investigation. These are discussed in the following pages.

BREEDING EXPERIMENT WITH DAIRY CATTLE

Comparison of Linebreeding with Outcrossing—Project 1

In view of the fact that this project will be conducted over a long period of time and will, therefore, not give any definite results until several years have passed, only progress can be reported at this time. No setbacks have taken place in the breeding work and several new animals have been added to the experiment during the past year. Several of the daughters of the orignial bull used in this breeding experiment have been on test during the year and have made generally very good records. The daughters of the first outcross in the experiment will be fresh during August and September. The experiment in no way conflicts with the general program of the breeding work in the dairy herd and is, therefore, an indirect asset.

Rations for Dairy Heifers During Winter Months—Project 5, Part II

The animals were divided into three groups.

Group I

Animals 148, 149, 159, 161, 430, 370, and 371 were fed grain, alfalfa hay and silage in the dry stock barn. This group was fed an average of 6 pounds of grain a day and hay and silage ad libitum.

Group II

Animals 62, 64, 158, 157, and 366 were allowed to run outside all winter, and an open shed was used for shelter. They were fed grain and silage in a trough and the alfalfa hay in racks. The animals were fed an average of 10 pounds of grain a day, and hay and silage ad libitum.

Group III

Animals 150, 151, 152, and 153 were fed alfalfa hay and silage ad libitum in the dry stock barn.

All of the animals in the three groups were weighed and measured on the fifteenth day of each month. Growth and weight were computed in per cent of normal, Eckle's normal figures being used.

All of the grain, hay, and silage fed to these animals was weighed and recorded.

The experimental feeding was started on November 1, 1925. Preliminary weights and measurements were taken October 15, 1925. Animals were turned out to pasture May 15, 1926, and the final weights and measurements were taken June 15, 1926.

All animals used on the experiment were yearling heifers. The grain ration used cost $42.00 a ton, silage $10.00, and hay $25.00.

The cost of feed per animal in group I was $69.31, in group II, $93.52, and in group III, $62.75.

	GROUP I		GROUP II		GROUP III	
	Height	Weight	Height	Weight	Height	Weight
	percentage of normal		*percentage of normal*		*percentage of normal*	
October	100.8	116.9	100.0	125.3	105.5	131.2
November	102.4	119.2	101.8	130.1	106.6	126.5
December	103.1	121.2	100.7	133.6	106.8	130.0
January	103.1	120.0	102.1	132.1	106.9	126.4
February	100.5	120.3	100.8	130.8	104.5	122.6
March	*101.7	120.9	*101.3	128.2	*105.8	125.8
April	101.7	127.6	101.7	127.2	105.2	127.9
May	†103.4	124.0	†102.0	127.3	†106.5	122.8
June	102.1	121.0	100.6	125.0	104.0	129.1

---

*Poor quality alfalfa hay was fed for balance of experiment.
†Animals went out on pasture.

Results

Groups I, II and III finished the experiment showing a percentage of height greater than at the start of experiment. After the first month on pasture all groups dropped from 1.3 per cent to 2.5 per cent.

The cold weather in February caused a percentage drop in height of all three groups and a percentage drop of weight in groups II and III.

Group III showed the greatest percentage loss in weight, but whereas groups I and II lost in weight percentage when put out to pasture, group III gained a fraction over 3 per cent in weight normal.

Conclusion

From the cost and condition standpoint it would seem that the results are in favor of the management of group I.

Minimum Milk Requirement for Raising Dairy Calves—

Project 6

This experiment was continued from last year.

The object is to find a satisfactory dry grain mixture to replace the milk in the ration fed to calves and also to find the earliest date at which a calf can be weaned from milk without retarding growth to any extent.

The following rations have been fed during the past year:

RATION No. 1

20 pounds yellow corn meal
10 pounds wheat bran
20 pounds skimmilk powder
30 pounds ground oats
20 pounds linseed oil meal
5 percent mineral mixture (salt, bone meal, and lime)

RATION No. 2

25 pounds yellow corn meal
37.5 pounds ground oats
5 percent mineral mixture
12.5 pounds wheat bran
25 pounds linseed oil meal
2 cc of 0.2 percent H Cl per pound of grain

This was changed for calves 170 and 171 by the addition of 25 pounds wheat middlings.

Procedure

The calves were accustomed to the dry feed at 3 weeks of age, and when they were 30 days of age all milk was taken away from them. They then received their respective grain mixtures and alfalfa hay and water ad libitum. The grain mixture was fed once a day at the same hour of the day. It was weighed into a clean pail and enough given so that usually a little was left at the next feeding period.

Each calf was weighed and measured for height at withers and heart girth on every ninth, tenth, and eleventh day from the time it started on the experimental ration. The averages were then taken to represent the weights and measurements on the tenth day.

Pictures of each calf, at a distance of 18 feet from the camera, were taken every 30 days.

At the end of the experimental period, the calves were turned over to the herdsman and fed the regular growing ration, consisting of 600 pounds hominy, 600 pounds wheat bran, 400 pounds oil meal, 400 ground oats, and 3 per cent mineral mixture. They also received alfalfa hay and silage, or pasture grass, according to the season.

Discussion

The calves were compared to Eckle's standard for weight and height. The percentages of normal at the beginning and end of the experiment are shown in table 1.

Several of the calves experienced a little difficulty in getting accustomed to the dry experimental ration, as was shown by subnormal gains for the first few weeks. After this, however, all of the calves except 162 picked up and made good gains, so that at the end of the experiment most of them were practically normal. The case of 162 was an exception. She made poor growth, developed

TABLE 1

Percentages of Normal Height and Weight Shown by Calves at Beginning and End of Experiment

Ration Number	Calf Number	Date Started on Experiment	30 Days of Age		180 Days of Age	
			Weight	Height	Weight	Height
			per cent	*per cent*	*per cent*	*per cent*
1	162	Apr. 22, 1925	88.4	97.5	63.4	91.1
1	165	June 14, 1925	76.0	93.6	90.6	92.7
1	435	June 14, 1925	76.2	100.1	91.6	96.9
2 2 cc. 0.2 per cent H Cl per pound grain	87	July 25, 1925	74.6	91.8	105.0	98.6
1	166	Aug. 1, 1925	101.6	106.4	100.3	101.1
1	436	Aug. 2, 1925	115.9	105.3	98.3	103.4
1	167	Aug. 27, 1925	83.7	95.5	94.6	97.4
2 1 cc. 0.2 per cent H Cl per pound grain	170	Dec. 6, 1925	100.0	102.5	108.3	99.0
2	171	Jan. 26, 1926	100.0	103.5	105.5	103.5

a cough, and became quite emaciated. After she was given the regular growing ration at the end of the experiment, she rapidly picked up and soon became normal in all ways.

The figures for 436 at 100 days of age are misleading. Her weight at 140 days of age was 109.5 per cent of normal, but at that time she injured one ankle, which was quite painful, and brought about a decrease in appetite and loss in weight which was not corrected at the end of the experiment.

None of the calves on ration 1 were troubled with scours, but those on ration 2 had mild but persistent spells of scouring at quite frequent intervals. This looseness did not seem to be accompanied by any discomfort, and the growth was evidently not affected. As this looseness in 87 was thought to be due possibly to the laxative nature of the ration, the ration was changed for 170 and 171 by the addition of 25 pounds of wheat middlings. This, however, did not prevent the trouble in these calves.

This experiment will be continued for several years, larger groups of calves being used so that more definite results may be secured.

Normal Growth of Dairy Animals—Project 10

Project 10 is being continued; measurements of height, weight, and heart girth are taken monthly. This work has been slowed up because many of our calves have been on nutrition experiments.

Effect of Temperature and Humidity on the Milk Production of Dairy Cows—Project 11, Part II

The humidity work has been held up by our inability to measure the humidity of the air with any degree of accuracy. A recording hygrograph has now been purchased by the department and the work has been started.

The Relation of the Ductless Glands to Milk Production—Project 13, Part II

Rabbits have been purchased for experimental animals. These animals are being bred up at the present time to insure a good supply of animals for the growth work.

Studies of the Color Pigmentation in the Skin of Dairy Cattle—Project 14

Considerable work has been done on this experiment in order to get a standard of measurement for skin pigment and the colorimetric reading of milk. Dr. Swett, of the United States Department of Agriculture, has sent us a copy of a pigment chart which can be used with a great deal of accuracy. A method of reading the color in milk has been developed by using the Meigs fat extraction process and comparing it to a known standard in a colorimeter.

This work will be started at once.

A Study of the Changes That Take Place in the Conformation of Dairy Cattle—Project 15

The materials for the photographic screen have been purchased and will be assembled for the study of these animals.

A Babcock-Gerber Method for Determining the Percentage of Fat in Ice Cream—Project 22

In the last few years numerous methods for determining the percentage of fat in ice cream have been submitted to the dairy industry. The most recent of these methods is the Troy-Fucoma method, which is a modification of the Gerber test for dairy products. Where careful and analytical results are desired, the Mojonnier method is to be recommended. The Mojonnier test, because of its cost, is impractical and expensive for the small ice cream manufacturer. Experiments with the Troy-Fucoma method have shown that this method checks closer with the Mojonnier than any of the other methods which are now in use for testing ice cream for butterfat. This experiment was undertaken with the belief that the reagents used in the Troyo-Fucoma test would work in the Babcock test bottle and thus eliminate the necessity of buying additional testing equipment.

Plan of Experiment and Experimental Methods

Forty samples of ice cream were tested by each of the three methods.

A. Babcock-Gerber Method. Since amyl alcohol is slightly soluble in butterfat in the preliminary trials with this method, the alcohol was used in the following amounts: 1.5, 1.8, and 2cc. It was found that 1.5 cc. of amyl alcohol did not give so clear and so well defined fat columns nor did the results check so closely with the Mojonnier as when 1.8 or cc. were used. In the Troy-Fucoma method 1 cc. of amyl alcohol is used per 5 gm. of ice cream, which is equivalent to 1.8 cc. of alcohol per 9 gm. of ice cream in the Babcock-Gerber method. In a few cases slightly higher results were secured by using 2 cc. of amyl alcohol. These results, however, were well within the experimental error and for actual practice the solubility of the amyl alcohol in butterfat is not great enough to be a factor in the test when only enough is used to secure a clear fat column. Both the 9-gm. 20 per cent ice cream bottles and the 9-gm. 50 per cent ice cream bottles were used in this experiment. Since the 9-gm. 20 per cent ice cream bottles are graduated in 0.2 per cent they should be used with this method. The samples were centrifuged in an electric non-heated tester. The directions for making the test are as follows:

1. Weigh exactly 9 gm. of well mixed sample into a 9-gm. 20 per cent ice cream test bottle.
2. Add 9 cc. of water and 1.8 cc. of amyl alcohol.
3. Mix thoroughly.
4. Add 17.5 cc. of diluted commercial sulfuric acid (94 cc. of acid to 6 cc. of water for chocolate ice cream, or 87 cc. of acid to 13 cc. of water for other flavors) in three proportions, mix thoroughly after each addition of acid, and finally give samples a vigorous shaking. (To obtain a clear fat column this is very important.)
5. Centrifuge for 5 minutes.
6. Add hot water to bring contents up to the bottom of the neck of the bottle.
7. Centrifuge for 2 minutes.
8. Add hot water to bring the bottom of the fat column well within the neck of the bottle.
9. Centrifuge for 1 minute.
10. Place bottles in a hot water bath at a temperature of 135° to 140°F. and leave for 5 minutes.
11. Remove each bottle as it is to be read, add red reader and read per cent of fat with dividers.

B. Gerber or Troy-Fucoma Method. Much difficulty was experienced with the Troy-Fucoma test in the preliminary trials and considerable time was spent in determining what method of procedure gave the best results. Troy's method as published by the Fucoma Company was first used and the results were very unsatisfactory both from standpoint of clearness of fat column and comparison to Mojonnier. The following method, which is a slight modification of the one recommended by Fisher and Walts (1), was found to give the best results.

1. Measure 10 cc. of diluted commercial sulfuric acid (94 cc. of acid to 6 cc. of water for chocolate ice cream, or 87 cc. of acid to 13 cc. of water for other flavors) into special ice cream test bottles.
2. Weigh exactly 5 gm. of well mixed sample into test bottle, using care to let the ice cream run down the side of the test bottle and spread over the surface of the acid without mixing it.

3. Add 5.5 to 6 cc. of water (depending on size of bottle) and 1 cc. of amyl alcohol; insert rubber stopper and mix contents by inverting test bottles until contents are thoroughly mixed.
4. Centrifuge immediately at a speed of 1000 to 1200 revolutions per minute for about 4 minutes.
5. Place in water bath at 135°F. and hold for about 5 minutes.
6. Centrifuge for 2 minutes.
7. As soon as centrifuging is complete, place in water bath at 135°F. for 5 minutes and read with dividers.

C. Mojonnier Method. The directions for testing ice cream for fat and total solids by the Mojonnier method as outlined by Mojonnier and Troy were followed exactly.[1]

Summary and Conclusions

1. The Babcock-Gerber method for determining the percentage of fat in ice cream is the adaption of the reagents in the Troy-Fucoma method applied to Babcock equipment.
2. To study the relative value of the Babcock-Gerber method as compared to the Troy-Fucoma and Mojonnier method 40 samples of ice cream were analyzed by these three methods.
3. There will be no appreciable degree of variation between the computed cate checks with the Troy-Fucoma method.
4. With the Mojonnier method being used as a standard for comparison, the results indicate that the Babcock-Gerber method is 231 per cent more accurate than the Troy-Fucoma.
5. The average percentage of variation from the Mojonnier on 40 samples was 0.44 per cent for Troy-Fucoma, 0.19 per cent for Babcock-Gerber with the 9-gm. 20 per cent ice cream bottles and 0.23 per cent with the 9-gm. 50 per cent cream bottles.
6. The Babcock-Gerber method seems well adapted for factory use where simplicity, cost of equipment, and time are important considerations; however, where accurate analytical results are desired the Mojonnier should be used.
7. With the Babcock-Gerber method, 67.5 per cent of all samples checked within 0.2 per cent, whereas with the Troy-Fucoma method, only 25 per cent of the samples checked within 0.2 per cent of the Mojonnier.
8. It would seem that the higher the total solids content, the more difficult it is to obtain accurac resuls when sulfuric acid is used as the solvent.

Effects of Ultraviolet Irradiation and Green Feed on the Mineral Constituents of the Blood and Milk of Cows on Adequate Diet, But Protected From Direct Sunlight—Project 23[2]

It has been shown conclusively that the ultraviolet component of sunlight influences the mineral metabolism of animals. Direct sunlight, or rays from a quartz-mercury vapor lamp act alike in increasing the calcium and inorganic phosphorus of the blood to normal amounts, and in bringing about normal calcification of the boney tissue in growing animals affected with rickets.

Most experimental workers report that irradiation with ultraviolet light increases the calcium and inorganic phosphorus in the blood of animals on diets deficient in minerals or in the antirachitic vitamin.

---

[1] Results of the above experiments have been published in the *Journal of Dairy Science,* Vol. 9:276-285, May, 1926; therefore, only conclusions will be given here.

[2] Conducted in cooperation with the department of agricultural biochemistry.

Hart, Steenbock, and co-workers have found that irradiation with ultraviolet light increased the calcium and phosphorus assimilation in mature, lactating goats, and increased slightly the calcium and inorganic phosphorus of the blood. These animals were on a low mineral diet.

Results of irradiation of animals on normal diets have been open to argument. Mayerson, Gunther, and Laurens (1925) report that in normal dogs irradiated 1 hour per day for 8 days, the blood calcium was decreased, but soon returned to normal. Irradiation for 2 hours daily, however, increased the blood calcium. Howe and Medlar (1924) working with humans. and Moritz (1925) working with rabbits, both concluded that the calcium and phosphorus were not affected in the blood serum of normal animals.

Results of several experiments seem to indicate that irradiation of lactating animals increases the antirachitic properties of the milk, but no extensive studies have been made on the mineral content of the milk from irradiated and non-irradiated animals.

Experimental results show that fresh green feeds usually increase the calcium assimilation of lactating animals, but special studies of the mineral content of the milk have not been made.

Plan of Experiment

Five liberally milking Holstein-Friesian cows of various ages and stages of lactation were used for this part of the experiment. Four of these were given the experimental treatments, and the other was used as a control animal. All were protected at all times from direct sunlight and an account was kept of the weights of all food eaten.. The animals were fed the regular test cow ration consisting of alfalfa hay, corn silage, beet pulp, and a concentrate mixture containing supplementary minerals in the form of lime and bone meal.

Records were kept of the daily milk and butterfat production, and tests were made for calcium and phosphorus (P_2O_5) in composite samples of one day's milk, twice a week. Blood samples were taken once a week, just after the morning milking, whole blood being drawn from the jugular vein, allowed to clot for about an hour, centrifuged, and the clear serum tested for calcium and inorganic phosphorus.

The animals were held under normal conditions for a few weeks to get the normal composition figures and fluctuations that occur. They were then exposed to ultraviolet rays from a Cooper-Hewitt mercury-vapor lamp with quartz tube, daily, for one month. The cows were confined in a small stall, allowing very little movement, and the lamp was suspended from the ceiling in such a position that the light was between two and three feet above the cow, and the entire back, excluding the head and neck, was exposed. The eyes were further protected by a burlap hood which was placed over the head.

Two of the cows were exposed for one-half hour a day for the entire period. The other two were increased to one hour a day for the last two weeks.

After one month of daily irradiation, the cows were held for two weeks without treatment. The following two weeks they were fed a liberal allowance of green alfalfa daily.

Results

Irradiation with ultraviolet light for one-half hour per day did not noticeably affect the amount of milk produced, the percentage of calcium or phosphorus in the milk, or the percentage of calcium or inorganic phosphorus in the blood of any of the cows.

There was some evidence that irradiation for one hour per day increased the calcium in the milk, but the other constituents of milk and blood were not affected.

Green alfalfa evidently did not alter the amount of milk produced or the mineral content of the blood or milk.

The effects of ultraviolet light on the biological food value of milk, on the growth of young animals, and on the amount and composition of milk from animals on a diet deficient in minerals or the antirachitic vitamin, were not studied in this experiment.

Work is to be continued on these problems in the near future at this Experiment Station.

A Comparison of the One-Day Sample vs. the Composite[1] Sample in the Analysis of Milk for Butterfat—Project 24

The purpose of this experiment was to show the actual variation in butterfat content that exists between the butterfat test of a one-day sample and a composite sample of milk.

Experimental Procedure

Samples of milk from 12 creamery patrons were taken daily for a period of 15 days. As soon as the samples had been collected each day they were taken to the laboratory where the percentage of butterfat in each was determined by means of the Babcock test. A portion of each sample was set aside in a jar to make up a composite sample for the entire period. These composite samples were divided into six different lots, the object being to determine the variation in fat, if any, due to the methods of handling and keeping the milk preserved for 15 days. Two of the lots were kept in rubber stoppered bottles, two in glass stoppered bottles, one in a capped bottle, and the other in an open bottle. In the case of the rubber and glass stoppered lots, the one bottle was mixed by means of a rotary motion and the other received a vigorous shaking. The cap stoppered lot received a rotary mixing and the open bottle was not mixed. Bichloride of mercury tablets were used as a preservative to keep the milk in good condition. In making these daily tests the milk was sampled at 60°F.[2]

---

[1] Conducted in cooperation with the department of agricultural biochemistry.

[2] Complete results of this experiment are being published in a future issue of the *Journal of Dairy Science* and only a discussion of results will be given here.

Discussion of Results

Considering these samples as a whole, it would seem that there is no great variation between the composite test and the computed average test for the 15-day period. Although all the samples show a slight variation between the computed average test and the composite test, these variations are well within the experimental error of conducting such an investigation. However, very few of the individual daily tests could be used as a comparison with the composite sample. The widest variation of a single daily sample from the composite was in the case of sample 9 which showed a variation of 0.9 per cent, this was very likely due to the fact that the amount of milk delivered on this day was over 100 pounds less than on the previous day. In seven cases, the variation of individual daily tests from the composite tests was over 0.5 per cent. Only 33 of the 144 daily tests, or less than one-fourth, were the same as the composite test. Therefore, it is not a good policy to try to compare any one day's test in a given period, with the results obtained by a composite sample.

Summary and Conclusions

1. The composite samples kept in a rubber-stoppered bottle and mixed by a rotary motion checked the closest with the computed average for the 15-day period; therefoe, this method of caring for composite samples is to be recommended.
2. Accurate results were not obtained by using an ordinary milk bottle with a cap stopper. Also a vigorous shaking of composite samples gave inaccurate results due to the churning of fat particles.
3. There will be no appreciable degree of variation between the computed average for the 15-day period and the composite test for the same when the samples are properly kept.
4. The fat content of milk from day to day is so variable that any one day's test cannot be taken as an index of the test of the composite sample which represents all the milk delivered during the 15-day period.

CREAMERY INSPECTION

The inspection of creameries in New Jersey is carried on under the administration of the Agricultural Experiment Station. Through this service the farmers in the state who sell milk on the basis of its butterfat content are protected. Any complaint received is always thoroughly analyzed and a fair decision given.

There are in the neighborhood of 5,000 farmers selling their product on this basis in New Jersey, and they are spread out over opproximately 88 creameries. In order to do satisfactory work, it is necessary to make at least three regular inspections of each creamery a year. Of course, there are a few who need a more constant investigation and these are generally visited at shorter intervals.

Inspection of Creameries

During the past year, 256 visits were made to 88 plants. Six or seven plants have closed and two new ones have been added to the list. A great deal of time has been spent on the taking of composite samples, of which 1,730 have been tested in duplicate. Many creamery operators overlook the fact that a daily sample is an absolute requirement of the law. This provision is being strictly enforced, and it has been found necessary to revoke several licenses for constant violations.

Glassware Inspection

A total number of 4,601 pieces of glassware were calibrated, of which 32 were found to be inaccurate. This is a rather high total when compared with previous years. For the first time in several years the glass companies failed to send in their year's supply during the winter. This seriously handicaps the system of work on hand.

Testers' Licenses

During the year, 209 testers' licenses were granted, 35 of which were new comers in the ranks. The policy of giving examinations in high schools was again carried out, with the result that about 75 per cent of the students received a passing grade.

Weighers' and Samplers' Permits

During the year, 75 permits were issued. This permit is given free of charge to employees of milk plants who weigh and sample the milk. It is also supposed to be had by all milk samplers employed by boards of health. By this method the employee is made directly responsible for the weighing of all milk received and for the correct sampling of the same.

Prosecutions

A permit to weigh and sample milk held by John Kane, of the Farmers' Exchange Company plant at South Branch, was definitely revoked and the holder fined $25.00. The charge covered a series of consistent violation of the law.

A permit to weigh and sample milk held by John Ewing, of the New Jersey Milk and Cream Company at Flemington, was definitely revoked. Charges have been made by the farmers of irregularities, which upon investigation were found to be justified.

A tester's license held by G. H. McPeek, of Lafayette, was revoked because of irregularities in butterfats over a period of a year.

Four men, found violating the law as a first offense, were put on probation. Any further violations by these men will mean a cancellation of their licenses.

Conclusions

The spirit of cooperation has been better this past year than for some time. More time will be spent on the correct methods of sampling and testing milk. The milk plant operators are realizing that samples must be taken daily in order to have an accurate representation of the milk purchased during the period of 15 days or a month.

EXTENSION

On July 1, 1925, E. A. Gauntt was added to the dairy extension force as assistant to E. J. Perry. With two extension men in the field the department has been better able to meet the demands for extension teaching. However, two men have not fully met all the demands upon their time, as the interest in dairy extension work seems to continue to grow. The specialists have met with dairy committees from each of the counties having dairy cattle and have drawn up extension programs for those counties. The projects listed under the several problems are as follows:

1. Cowtesting associations
2. Junior dairy work (calf clubs)
3. Purebred sire campaigns
4. Improved feeding
5. Individual record keeping
6. Dairy tours
7. Miscellaneous, such as tuberculosis eradication, exhibits.

Two hundred and four dairymen are now members of cowtesting associations in the state. These 204 members own approximately 5,000 dairy cows. Two new full-time associations have been organized during the year in Warren and Cumberland counties. The cowtesting association seems to be gaining in popularity as a good business proposition for the dairy farmer. During the year county agents and testers have come together at the Agricultural College to discuss problems incident to cowtesting and record work. These conferences have done much to make for a better understanding among the agents, the dairy departments, and the cowtester. Monthly reports of record cows and the work of the association are being published in several county papers.

The junior dairy work has received considerable attention during the year. Four hundred and thirty-four boys and girls now own 671 purebred animals. These figures are an increase over 1924 of 110 new members in this type of work. The specialist has helped find sources of good animals for boys and girls wishing to take up this project. He also helped agents to find new members and to organize new clubs. Subject matter on feeding and dairy management has been furnished club members through meetings and monthly news letters. Instruction has been given in judging, feeding, and showing. The newspapers have been very anxious to cooperate in giving proper publicity to the work of the boys and girls. During the summer the dairy husbandman spent come time in the state with the extension specialists in selecting representatives of the different breeds of dairy cattle to be shown at the State Fair and the National Dairy Show. New Jersey boys and girls were fortunate in winning at the 1925 National Show first place with Holsteins, Guernseys, and Jerseys. This state was represented by a show herd of four animals of each of the above breeds in competition with several other states of much greater importance in the dairy industry. A New Jersey boy had the grand champion calf in the junior show at the National in 1925. There is no doubt but that this junior work is a very much worth while project and will evidently make for a higher standard of dairying in the state.

The campaign to replace scrub bulls with purebreds has been continued through the year. Through the extension service, 81 purebred bulls replaced grades or scrubs in Warren and Sussex counties. This type of work is of immense value and should be contiued as a major project for many years to come.

Eighteen meetings on better methods of feeding have been held, at which approximately 1,000 dairymen have been present, and have received first hand the message of better feeding methods.

The monthly feeding service in New Jersey Agriculture has been continued and reports have come to this office of the value of this service to the dairymen throughout the state. Five hundred letters have been written in answer to questions on feeding.

In several counties dairy tours were taken with a definite and interested itinerary. These tours took dairymen to some of the best managed herds in the state where improved practices are being followed. Such tours were held in seven of the dairy counties and approximately 400 farmers took part.

Improvement in health of cattle has been one of the projects that has received attention during the year. Through the cooperation of the New Jersey Bureau of Animal Industry, dairy extension agents and county agents are able to report over 3,000 dairy herds now under state and federal supervision for the eradication of tuberculosis. Several herds in the state are practicing the blood test method to eradicate contagious abortion. As a direct result of educational efforts of extension workers it is estimated that 200 herds of cattle; or approximately 4,000 animals, have been added to the list under federal and state supervision during the year.

Close cooperation has existed between the state breed associations and the extension service. The State Guernsey Breeders' Association has continued its activities with William M. Nulton, Jr., as field representative. As Mr. Nulton has an office in the dairy building it has been possible to cooperate closely with him in his work. He has been responsible for the placing of 56 purebred Guernsey bulls on farms in the state during the year. One of the chief accomplishments of the Guernsey Breeders' Association has been the establishment of roadside markets for the sale of Guernsey milk. This type of project has met with success and has been recommended by the Breed Association.

Although members of the teaching staff of the department have not spent many days in the field, there has been very close cooperation between the faculty and the county agents. At every meeting of the department faculty the extension men have been in attendance.

ADVANCED REGISTRY

No decided changes have taken place in advanced registry testing during the past year. A staff of competent supervisors was maintained and all requests for supervision have been attended to. Also check tests were supervised in other states, as Connecticut, Massachusetts, New Hampshire, Pennsylvania, Delaware, Maryland, and New York.

Supervisors' reports were checked in the office and reports mailed to the various dairy breed organizations. All data pertaining to advanced registry testing were kept in the office. Data pertaining to "percentage of increase over requirement" for entry into the various advanced registry classes, as well as data giving "mature fat equivalents," were computed.

Lists showing state and national champions of all dairy breeds were distributed. Correspondence was carried on relating to advanced registry testing, feeding, and general management. Close to 400 farms were visited for the purpose of inspecting the work of the supervisors and to call on breeders. Advice was given relating to the selection of animals, and pedigrees were compiled. State and national supervision for the eradication of tuberculosis has been advised with good results.

Some time was spent with the students' judging team. Some cattle sales were attended, as were meetings of dairy organizations. Articles for New Jersey Agriculture and Green Sheets were prepared as well as many other articles for the newspapers.

The New Jersey Herd Test established during the past year, is being tried out with good success, and it is believed that this part of advanced registry testing will be greatly developed.

SUMMARY OF TESTING FOR THE YEAR 1925-26

Cows Tested Semi-Officially	
Jersey	64
Guernsey	247
Holstein	240
Ayrshire	18
Brown Swiss	9

Total Number of Semi-Official Tests	
Jersey	331
Guernsey	1526
Holstein	1295
Ayrshire	137
Brown Swiss	27

Total number of semi-official tests	3416
Number of breeders doing semi-official testing	57
Number of breeders doing official testing	13
Total number of breeders doing testing	70
Number of supervisors used for official tests	10
Number of supervisors used for semi-official tests	23

Number of Official Records Completed	
7-day records	65
15-day records	1
30-day records	13
60-day records	0
90-day records	0

THE DAIRY HERD

During the year an average of 115 dairy animals has been maintained. With an increase in the number of young milking animals the average production for the year was not so great as during the year 1924. The average number of cows milking has been 39 with an average yearly production for all breeds in the herd of 8,901.8 pounds of milk per cow. The income from the sale of milk and stock was $21,283.86.

It has been found profitable to milk most of the animals three times daily for the first few months of their lactation period; therefore, approximately 30 animals have been carried under advanced registry conditions throughout the year. It has been interesting to note that in several cases cows have doubled their production of the previous lactation when milked three times daily instead of two. This station has had the honor during the year of having a world's record Holstein cow as well as a State Champion Jersey. These two animals have given the herd considerable publicity and have brought favorable comment to the work being done in making records.

An appropriation of $8,000 was made by the Legislature during the past season for the construction of a calf barn. This barn will meet the increasing need for more research work with young animals. Through the kindness of interested breeders some valuable additions have been made to the list of herd sires. Mr. L. F. Loree has loaned us a very high-class Guernsey bull to head the Guernsey herd here. Another gift to the institution was made by Mrs. Bliss, of Wendover Farms, in the presentation of a son of the famous Ayrshire show bull, Admiral Beatty. With the acquisition of a very fine Jersey bull, which has been an outstanding show ring winner, the College and Station herd is headed by sires which compare very favorably with those of any breeding establishment.

HERD INVENTORY—ANIMALS IN HERD JUNE 30, 1926

Number of females 3 years old or over	41
Number of females 2 to 3 years old	12
Number of females 1 to 2 years old	11
Number of females under 1 year	37
Number of bulls 3 years old or over	1
Number of bulls 2 to 3 years old	2
Number of bulls 1 to 2 years old	3
Number of bulls under 1 year	8

Report of the Department of Entomology

THOMAS J. HEADLEE

INTRODUCTION

The department of entomology is concerned with the following projects:

(1) Mosquito Control; (2) Climate and Insect Investigations; (3) Orchard Insect Investigations; (4) Investigations of Dusts and of Spreaders, Stickers and Diluents for Spraying and Dusting Mixtures; (5) Small Fruit Insect Investigations; (6) Vegetable Insect Investigations; (7) Arthropods Injurious to Poultry Production; (8) Insects Injurious to Market Milk; (9) Investigations in Cranberry Problems; (10) Greenhouse Insect Investigations; (11) Soil Infesting Insect Investigations; and (12) Bee Investigations.

Certain phases of projects 1, 2, 3, 4, 5, 9, 11 and 12 have been actively pursued, while the rest of the projects have been temporarily inactive.

The entomologist, in addition to exercising a general oversight on all departmental operations, has given especial attention to projects 1 and 2, that portion of project 3 dealing with codling moth and European red mite, project 5, and to project 11. Prof. Clyde C. Hamilton has devoted his attention to the investigation of the adhesion of lead arsenate to the foliage and fruit of apple, to certain necessary side chain and certain necessary miscellaneous studies. Mr. Louis A. Stearns has continued to devote his time to the oriental peach moth investigation. Dr. Joseph M. Ginsburg, who was appointed July 1, 1925, on a full time basis as biochemist of the department, has devoted his attention to the problems in connection with the investigation of dusts and of stickers, spreaders and diluents for spraying and dusting mixtures and to certain problems in connection with mosquito control. Mr. Frank W. Miller has devoted his attention to the problem of practical mosquito control. Mr. Charles S. Beckwith has continued his investigations of cranberry and blueberry culture, with the assistance of Mr. Byrley F. Driggers and Mr. Carl D. Jones. Mr. Carl Ilg has continued his work as assistant to the entomologist in his investigations and as assistant curator of the insect collection. Mr. Ray Hutson has continued his apicultural investigations, giving his attention to project 12.

CORRESPONDENCE

For the purpose of maintaining the record of insect occurrence, upon which it is hoped later studies on insect periodicity may be made, the insect correspondence record is submitted. This record shows that 630 inquiries concerning insects were received and answered during the year and that these inquiries pertain to 225 different species of injurious insects. All told, the volume of correspondence referring to injurious and beneficial arthropods amounts to more than 7,000 letters written and sent out. This takes no account either of the mail sent out in connection with the work of the New Jersey Mosquito Extermination Association or the Cranberry Substation, which amounts this year to more than 5,000 pieces.

Crustacea

Latin Name	*Common Name*	*Locality*	*Date*
Porcellio vulgare Lat.	Sow bug	Long Branch	Sept. 24, '25
Porcellio vulgare Lat.	Sow bug	East Orange	Mar. 30, '26
Arachnida			
Bryobia pratensis Gar.	Clover mite	Paterson	Dec. 3, '25
Dermacentor variabilis Say.	Common dog tick	Port Jervis	July 1, '25
Eriophyes pyri Pgst.	Pear leaf blister mite	Morristown	July 21, '25
Eriophyes quadripes Shin.	Maple bladder gall mite	Hackensack	July 1, '25
Eriophyes quadripes Shin.	Maple bladder gall mite	Hackensack	July 13, '25
Glyptocranium cornigerum Em.	Spider	Madison	Sept. 21, '25
Parasitus sp.	Mite	Woodbury	Mar. 4, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Brielle	July 30, '25
Paratetranychus pilosus Can. & Fanz.	European red mite	Camden	Aug. 4, '25
Paratetranychus pilosus Can. & Fanz.	European red mite	Camden	Nov. 13, '25
Paratetranychus pilosus Can. & Fanz.	European red mite	Camden	Dec. 11, '25
Paratetranychus pilosus Can. & Fanz.	European red mite	Fitchburg, Mass.	Jan. 13, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Blackwood	Jan. 26, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Flemington	Jan. 26, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Gibbsboro	Jan. 26, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Hightstown	Jan. 26, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Franklin Park	Feb. 6, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Mount Wold, Pa.	Feb. 11, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Pineville, Pa.	Feb. 11, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Vineland	Feb. 11, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Annandale	Feb. 23, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Matawan	Feb. 23, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Morristown	Feb. 23, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Skillman	Feb. 23, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Bridgeton	Feb. 25, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Glassboro	Mar. 11, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Philadelphia	Mar. 16, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Woodbury	Mar. 19, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Ridgewood	Mar. 30, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Clinton	Mar. 30, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Perth Amboy	Apr. 21, '26

Arachnida--Continued

Latin Name	Common Name	Date	Locality
Paratetranychus pilosus Can. & Fanz.	European red mite	Hightstown	May 11, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Minotola	May 21, '26
Paratetranychus pilosus Can. & Fanz.	European red mite	Paterson	May 28, '26
Paratetranychus ununguis Jacobi	Spruce mite	Trenton	Apr. 26, '26
Tetranychus telarius Linn.	Common Greenhouse red spider	Waldwick	July 23, '25
Tetranychus telarius Linn.	Common Greenhouse red spider	Bernardsville	Aug. 4, '25
Tetranychus telarius Linn.	Common Greenhouse red spider	New York City	Aug. 6, '25
Tetranychus telarius Linn.	Common Greenhouse red spider	New York City	Aug. 14, '25
Tetranychus telarius Linn.	Common Greenhouse red spider	Camden	Nov. 13, '25
Trombidium sericeum Say.	Mite	Belmar	Apr. 21, '26
	Myriapoda		
Chilognattia	Thousand legged worm	Oxford	July 3, '25
	Insecta		
	Isoptera		
Termes flavipes Koll	White ant	East Orange	Aug. 4, '25
Termes flavipes Koll	White ant	Irvington	Sept. 24, '25
Termes flavipes Koll	White ant	South Orange	Feb. 18, '26
Termes flavipes Koll	White ant	Syracuse	Feb. 18, '26
Termes flavipes Koll	White ant	Somerville	May 20, '26
Termes flavipes Koll	White ant	Cranford	June 18, '26
	Corrodentia		
	Bark louse	New Brunswick	Oct. 22, '25
Atropos pulsatoria Linn.	Book louse	Trenton	Jan. 19, '26
	Trichoptera		
Phryganeidae	Caddice fly	Hackensack	June 17, '26
	Thysanoptera		
Heliothrips haemorhoidalis Bouche	Greenhouse thrips	Princeton	July 21, '25
Thrips tabaci Linden	Onion thrips	Woodbury	Feb. 5, '26
		East Orange	May 21, '26
	Homoptera		
Aleyrodes vaporarium West	Greenhouse white fly	Keyport	Dec. 30, '25
Aphididae	Plant louse	Keyport	Dec. 30, '25

Homoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Aphis avenae Fab.	Oat aphis	Ontario, Canada	Mar. 10, '26
Aphis pomi De Geer	Green apple louse	Roselle Park	Sept. 15, '25
Aphis pomi De Geer	Green apple louse	Elizabeth	Sept. 30, '25
Aphis pomi De Geer	Green apple louse	Flemington	Oct. 28, '25
Aphis pomi De Geer	Green apple louse	Flemington	Jan. 20, '26
Aphis pomi De Geer	Green apple louse	Mt. Wolf, Pa.	Jan. 20, '26
Aphis pomi De Geer	Green apple louse	Atlantic Highlands	Mar. 1, '26
Aphis pomi De Geer	Green apple louse	Ontario, Canada	Mar. 10, 26
Aphis sorbi Kalt.	Rosy apple aphis	New Brunswick	May 28, '26
Aphis sorbi Kalt.	Rosy apple aphis	Jamesburg	June 12, '26
Aphis sorbi Kalt.	Rosy apple aphis	Elizabeth	June 18, '26
Aspidiotus forbesi John.	Cherry scale	East Orange	Nov. 19, '25
Aspidiotus forbesi John.	Cherry scale	East Orange	June 17, '26
Aspidiotus perniciosus Comst.	San Jose scale	New Brunswick	Aug. 26, '25
Aspidiotus perniciosus Comst.	San Jose scale	New York	Apr. 21, '26
Asterolecanium variolosum Rabs.	Golden oak scale	Trenton	Apr. 23, '26
Chaitophorus aceris Linn.	Maple chaitophrus	Califon	Aug. 17, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Woodbury	Aug. 27, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Califon	Aug. 17, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Califon	Sept. 9, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Annandale	Sept. 15, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Short Hill	July 7, '25
Chaitophorus aceris Linn.	Maple chaitophrus	Far Hills	May 26, '26
Chermaphis abietis Linn.	Spruce gall louse	High Bridge	July 8, '25
Chermaphis abietis Linn.	Spruce gall louse	Upper Mountclair	Aug. 6, '25
Chermaphis abietis Linn.	Spruce gall louse	Woodbury	Aug. 7, '25
Chermaphis abietis Linn.	Spruce gall louse	Red Bank	Jan. 19, '26
Chermaphis abietis Linn.	Spruce gall louse	Morristown	Feb. 11, '26
Chermaphis abietis Linn.	Spruce gall louse	South Orange	Mar. 29, '26
Chermaphis abietis Linn.	Spruce gall louse	Short Hill	Apr. 29, '26
Chermaphis abietis Linn.	Spruce gall louse	Chatham	May 21, '26
Chermaphis abietis Linn.	Spruce gall louse	Oakland	June 17, '26
Chermaphis abietis Linn.	Spruce gall louse	New Brunswick	June 23, '26
Chermes cooleyi Gill	Spruce gall louse	Morristown	Feb. 11, '26
Chermaphis pinicorticis Fitch.	Pine bark aphis	Leonia	Sept. 24, '25

Homoptera—Continued

Latin Name	Common Name	Locality	Date
Chermaphis pinicorticis Fitch.	Pine bark aphis	Glassboro	May 28, '26
Chermaphis pinicorticis Fitch.	Pine bark aphis	Moorestown	June 3, '26
Chermaphis pinicorticis Fitch.	Pine bark aphis	New Brunswick	June 16, '26
Chionaspis euonymi Comst.	Euonymus scale	New York City	Oct. 9, '25
Chionaspis euonymi Comst.	Euonymus scale	Belmar	Nov. 4, '25
Chionaspis euonymi Comst.	Euonymus scale	Plainfield	Nov. 19, '25
Chionaspis euonymi Comst.	Euonymus scale	Woodcliff Lake	Mar. 30, '26
Chionaspis euonymi Comst.	Euonymus scale	Upper Montclair	Apr. 14, '26
Chionaspis furfurus Fitch	Scurfy scale	East Orange	July 3, '25
Chionaspis pinifoliae Fitch	Pine leaf scale	Englewood	July 7, '25
Chionaspis pinifoliae Fitch	Pine leaf scale	Leonia	Sept. 24, '25
Chionaspis pinifoliae Fitch	Pine leaf scale	Burlington	Oct. 13, '25
Chionaspis pinifoliae Fitch	Pine leaf scale	Plainfield	May 5, '26
Cladobius saliciti Harr.	Willow louse	Allentown	Oct. 23, '25
Diedrocephala coccinea Forth.	Leaf hopper	Red Bank	July 21, '25
Empoasca mali L. B.	Apple leaf hopper	Lebanon	June 10, '26
Eulecanium tulipifera Cook.	Tulip soft scale	Metuchen	July 13, '25
Eulecanium tulipifera Cook.	Tulip soft scale	Califon	Aug. 1, '25
Eulecanium tulipifera Cook.	Tulip soft scale	Belvidere	Sept. 19 '25
Gossyparia spuria Mod.	European elm scale	Westfield	June 11, '26
Hormaphis hamamelidis Fitch.	Witch hazel cone gall	Plainfield	Sept. 23, '25
Lecanium corni Bouche	European fruit lecanium	Gibbsboro	Nov. 12, '25
Lecanium corni Bouche	European fruit lecanium	Camden	Mar. 10, '26
Lecanium nigrofasciatum Perg.	Peach lecanium	Blackwood	Jan. 26, '26
Lepidosaphes ulmi Linn.	Oyster shell scale	Plainfield	Aug. 10, '25
Lepidosaphes ulmi Linn.	Oyster shell scale	Bernardsville	Oct. 29, '25
Lepidosaphes ulmi Linn.	Oyster shell scale	Little Silver	Dec. 3, '25
Lepidosaphes ulmi Linn.	Oyster shell scale	Elizabeth	Apr. 24, '26
Lepidosaphes ulmi Linn.	Oyster shell scale	Plainfield	May 5, '26
Lepidosaphes ulmi Linn.	Oyster shell scale	South River	May 20, '26
Lepidosaphes ulmi Linn.	Oyster shell scale	Cranbury	May 28, '26
Longistigma caryae Harr.	Hickory aphis	Woodbury	Sept. 19, '25
Myzus ribis Des.	Currant aphis	Pennington	Mar. 8, '26
Nectarophora rosae Linn.	Rose aphis	Dunellen	Jan. 26, '26
Nectarophora rosae Linn.	Rose aphis	Vineland	Apr. 29, '26

Homoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Neolecanium cornuparvum Thos.	Magnolia soft scale	Cape May Court House	Apr. 12, '26
Pemphigus populicaulis Fitch.	Poplar stem gall	Mays Landing	July 8, '25
Phenacoccus acericola King	Maple false scale	Elizabeth	June 23, '26
Phylloxera caryaecaulis Fitch.	Hickory gall aphis	Dover	June 11, '26
Phylloxera vastatrix Plauch	Grape phylloxera	Bordentown	Aug. 27, '25
Prociphillus tessellatus Fitch.	Woolly maple louse	Princeton	July 3, '25
Pseudococcus citri Risso.	Common mealy bug	Hackensack	July 1, '25
Pseudococcus comstocki Kuw.	Mealy bug	Plainfield	Oct. 16, '25
Psylla pyricola Forst.	Pear psylla	Hightstown	Nov. 18, '25
Psylla pyricola Forst.	Pear psylla	Morristown	Feb. 6, '26
Psylla pyricola Forth.	Pear psylla	Hightstown	Feb. 25, '26
Pulvinaria innumerabilis Ratho.	Cottony maple scale	Little Silver	July 3, '25
Saissetia hemisphaerica Targ.	Hemispherical scale	Mountain Lake	Dec. 5, '25
Saissetia hemisphaerica Targ.	Hemispherical scale	Newark	Mar. 10, '26
Saissetia hemisphaerica Targ.	Hemispherical scale	Blairstown	Mar. 30, '26
Saissetia hemisphaerica Targ.	Hemispherical scale	Englishtown	Apr. 7, '26
Saissetia hemisphaerica Targ.	Hemispherical scale	Mendham	Apr. 21, '26
Saissetia oleae	Black scale	Branchville	June 3, '26
Schizoneura lanigera Hausn.	Woolly apple aphis	Hasbrouck Heights	Aug. 4, '25
Schizoneura lanigera Hausn.	Woolly apple aphis	Dumont	Mar. 5, '26
Typhlocyba comes Say.	Grape leaf hopper	South Elizabeth	Sept. 24, '25
Typhlocyba comes Say.	Grape leaf hopper	Millville	June 22, '26
Orthoptera			
Blattella germanica Linn.	German cockroach	Newton	Sept. 19, '25
Blattella germanica Linn.	German cockroach	Riverton	July 28, '25
Diestramena marmorata Haan.	Japanese camel cricket	Morristown	Aug. 27, '25
Gryllus domesticus Linn.	House cricket	Hackensack	Aug. 8, '25
Melanoplus femur-rubrum De. G.	Red-legged grasshopper	Stockton	Aug. 31, '25
Microcentrum rhombifolium Sauss.	Katydid	Haddonfield	Sept. 9, '25
Microcentrum rhombifolium Sauss.	Katydid	Atlantic Highlands	Mar. 30, '26
Microcentrum rhombifolium Sauss.	Katydid	Mays Landing	Apr. 29, '26
Paratenodera sinensis Sauss.	Chinese praying mantis	Long Branch	Aug. 27, '25
Paratenodera sinensis Sauss.	Chinese praying mantis	New Brunswick	Aug. 31, '25
Paratenodera sinensis Sauss.	Chinese praying mantis	Pleasantville	Sept. 9, '25

Orthoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Paratenodera sinensis Sauss.	Chinese praying mantis	Haddonfield	Dec. 16, '25
Paratenodera sinensis Sauss.	Chinese praying mantis	Woodbury	Apr. 14, '26
Paratenodera sinensis Sauss.	Chinese praying mantis	Pemberton	May 5, '26
	Hemiptera		
Apateticus sp.	Stink bug	Brooklyn	Sept. 24, '25
Apateticus maculiventris Say.	Stink bug	Belmar	Sept. 24, '25
Apateticus maculiventris Say.	Stink bug	Mt. Holly	June 18, '26
Blissus leucopterus Say.	Chinch bug	Perth Amboy	Nov. 4, '25
Cimex lectularius	Common bed bug	Paterson	Aug. 17, '25
Cimex lectularius Linn.	Common bed bug	Hillside	Jan. 16, '26
Cimex lectularius Linn.	Common bed bug	Hillside	Jan. 18, '26
Cimex lectularius Linn.	Common bed bug	Freehold	Mar. 30, '26
Cimex lectularius Linn.	Common bed bug	Unon City	Apr. 17, '26
Cimex lectularius Linn.	Common bed bug	Mantua	May 31, '26
Cimex lectularius Linn.	Common bed bug	Northfield	June 23, '26
Corythuca ciliata Say.	Sycamore lace bug	Freehold	Aug. 26, '25
Corythuca ciliata Say.	Sycamore lace bug	Woodbury	Aug. 27, '25
Leptobyrsa rhododendri How.	Rhododendron lace bug	West Orange	May 5, '26
Lygidea mendox Reuter	False apple red bug	Cape May	Sept. 23, '25
Lygidea mendox Reuter	False apple red bug	New Brunswick	Sept. 30, '25
Lygidea mendox Reuter	False apple red bug	Camden	Mar. 10, '26
Nezara hilaris Say.	Green soldier bug	New Brunswick	Aug. 22, '25
Nezara hilaris Say.	Green soldier bug	Washington, Va.	Aug. 27, '25
Poecilocapsus lineatus Fab.	Four lined leaf bug	Belvidere	June 7, '26
Poeciloscytus basalis Rent.	Plant bug	New Brunswick	Nov. 14, '25
Stiretrus anchorago Fab.	Stink bug	Morristown	July 2, '25
Thyreocaris pulicaria Gorm.	Negro bug	Elmer	July 3, '25
Thyreocaris pulicaria Gorm.	Negro bug	New Brunswick	Nov. 14, '25
Triphleps insidiosus Say.		New Brunswick	Nov. 14, '25
	Coleoptera		
Adalia bipunctata Linn.	Two spotted lady beetle	Millville	July 30, '25
Adalia bipunctata Linn.	Two spotted lady beetle	Maplewood	Oct. 28, '25
Alaus oculata Linn.	Eyed Elater	New Brunswick	Nov. 14, '25
Allorhyna nitida Linn.	June beetle	Red Bank	July 21, '21

Coleoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Allorhyna nitida Linn.	Green June beetle	Red Bank	Aug. 27, '25
Allorhyna nitida Linn.	Green June beetle	Trenton	Sept. 4, '25
Anomala lucicola Fab.	Vine chafer	Mt. Holly	July 21, '25
Anomala lucicola Fab.	Vine chafer	Paterson	July 25, '25
Anthonomus signatus Say.	Strawberry weevil	Puyallup, Wash.	Dec. 11, '25
Anthrenus scrophularia Linn.	Carpet beetle	Newark	Nov. 4, '25
Anthrenus scrophularia Linn.	Carpet beetle	Freehold	Mar. 30, '26
Anthrenus verbasci Linn.	Museum beetle	Plainfield	Mar. 19, '26
Apion spec.	Snout beetle	New Brunswick	Nov. 14, '25
Attagenus piceus Oliv.	Black carpet beetle	New Brunswick	Mar. 2, '26
Bruchus obtectus Say.	Bean weevil	South Vineland	July 1, '25
Bruchus obtectus Say.	Bean weevil	Mullica Hill	Sept. 8, '25
Bruchus obtectus Say.	Bean weevil	Thorofare	Dec. 11, '25
Bruchus obtectus Say.	Bean weevil	Jamesburg	Apr. 29, '26
Bruchus obtectus Say.	Bean weevil	Elizabeth	May 28, '26
Bruchus obtectus Say.	Bean weevil	Rochelle Park	June 3, '26
Calandra granaria Linn.	Granary weevil	Paterson	Sept. 23, '25
Calandra granaria Linn.	Granary weevil	Jamesburg	Mar. 4, '26
Calandra cryzae	Rice weevil	Paterson	Sept. 23, '25
Callidium antennatum Newm.	Blue pine borer	Woodstown	Apr. 14, '26
Ceutorhynchus rapae Gyll.	Cabbage curculia	New Brunswick	Nov. 14, '25
Chrysobothris dentipes Gorm.	Flat headed borer	Cresskill	Oct. 13, '25
Chrysobothris femorata Fab.	Flat headed apple tree borer	Merchantville	Apr. 21, '26
Chrysobothris femorata Fab.	Flat headed apple tree borer	Whippany	Apr. 29, '26
Chrysochus auratus Fab.	Milk weed gold bug	Titusville	July 13, '25
Chrysochus auratus Fab.	Milk weed gold bug	Freehold	July 21, '25
Chrysochus auratus Fab.	Milk weed gold bug	Bordentown	Aug. 7, '25
Chrysochus auratus Fab.	Milk weed gold bug	Belvidere	Aug. 4, '25
Cicindela silvicola	Tiger beetle	Cremona, Italy	Aug. 10, '25
Conotrachelus nenuphar Hbt.	Plum curculia	Yonkers, N. Y.	July 7, '25
Conotrachelus nenuphar Hbt.	Plum curculia	Westfield	July 30, '25
Conotrachelus nenuphar Hbt.	Plum curculia	Phillipsburg	Sept. 15, '25
Conotrachelus nenuphar Hbt.	Plum curculia	Dumont	Mar. 5, '26
Conotrachelus nenuphar Hbt.	Plum curculia	Dover	June 11, '26

Coleoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Coptocycla signifer Hbt.	Mottled tortoise beetle	Newark	Aug. 31, '25
Criocerus asparagi Linn.	Aspaagus beetle	Lower Jamesburg	July 21, '25
Cryptorhynchus lapathi Linn.	Common willow and poplar borer	New Brunswick	May 26, '26
Cyllene robiniae	Locust borer	Trenton	May 26, '26
Desmocerus palliatus Forst.	Cloaked knotty horn beetle	Pequanack	Mar. 6, '26
Desmocerus palliadus Forst.	Cloaked knotty horn beetle	Westville	June 23, '26
Diabratica vittata Fab.	Striped cucumber beetle	Cranbury	Apr. 14, '26
Diabratica vittata Fab.	Striped cucumber beetle	Minotola	June 24, '26
Dicaelus dilatatus Say.	Ground beetle	Hamburg	June 11, '26
Dichelonycha albicollis Burm.		Elizabeth	July 7, '25
Elaphidion villosum Fab.	Oak twig prunen	Plainfield	Mar. 5, '26
Elateridae sp.	Wire worm	New Haven, Conn.	Feb. 25, '26
Elateridae sp.	Wire worm	Creamridge	May 21, '26
Elateridae sp.	Wire worm	Paterson	June 3, '26
Elateridae sp.	Wire worm	Elizabeth	June 24, '26
Elateridae sp.	Wire worm	Westfield	June 24, '26
Epicauta cinerea Forst.	Gray blister beetle	Trenton	July 28, '25
Epicauta cinerea Forst.	Margined blister beetle	Hampton	Aug. 6, '25
Epicauta cinerea Forst.	Margined blister beetle	Middlebush	Aug. 6, '25
Epicauta marginata Fab.	Margined blister beetle	Clinton	July 23, '25
Epicauta pennsylvanica De. G.	Black blister beetle	Hilton	Aug. 20, '25
Epicauta pennsylvanica De. G.	Black blister beetle	Fair Haven	Aug. 27, '25
Epicauta pennsylvanica De. G.	Black blister beetle	Paterson	Aug. 27, '25
Epicauta pennsylvanica De. G.	Black blister beetle	Cape May	Sept. 4, '25
Epicauta vittata Fab.	Striped potato beetle	Lebanon	July 21, '25
Epitrix cucumeris Harr.	Cucumber flea beetle	Ridgewood	May 28, '26
Galerucella cavicollis Lecombe	Cherry leaf beetle	High Bridge	July 21, '25
Galerucella cavicollis Lecombe	Cherry leaf beetle	Stewartsville	July 22, '25
Galerucella luteola Mull.	Elm leaf beetle	Upper Montclair	July 8, '25
Galerucella luteola Mull.	Elm leaf beetle	Upper Montclair	July 14, '25
Galerucella luteola Mull.	Elm leaf beetle	Upper Montclair	July 23, '25
Galerucella luteola Mull.	Elm leaf beetle	Montclair	July 29, '25
Galerucella luteola Mull.	Elm leaf beetle	Gladdonfield	Dec. 30, '25
Galerucella luteola Mull.	Elm leaf beetle	Ridgewood	Mar. 30, '26

Coleoptera--Continued

Latin Name	Common Name	Locality	Date
Galerucella luteola Mull.	Elm leaf beetle	New Brunswick	May 28, '26
Galerucella luteola Mull.	Elm leaf beetle	Morristown	June 3, '26
Galerucella luteola Mull.	Elm leaf beetle	Montclair	June 9, '26
Gastroidea polygani Linn.		New Brunswick	Nov. 5, '25
Haltico chalybea Ill.	Grape flea beetle	New Brunswick	Aug. 4, '25
Lachnosterna fusca Froehl.	White grub	Rahway	July 23, '25
Lachnosterna sp.	White grub	Plainfield	Oct. 14, '25
Lasioderma serricorne Fab.	Cigarette beetle	Closter	Sept. 21, '25
Macrobasis unicolor Kirby	Ash-gray blister beetle	Clinton	July 28, '25
Macrodactylus subspinosus Fab.	Rose chafer	Paterson	July 8, '25
Macrodactylus subspinosus Fab.	Rose chafer	Dunellen	Jan. 26, '26
Macrodactylus subspinosus Fab.	Rose chafer	Elizabeth	May 26, '26
Macrodactylus subspinosus Fab.	Rose chafer	Allenhurst	June 24, '26
Melasoma scripta Fab.	Cottonwood leaf beetle	Woodbury	Aug. 27, '25
Melasoma scripta Fab.	Cottonwood leaf beetle	Bridgeton	Sept. 8, '25
Meloe americanus Leach.	Blister beetle	Palmyra	Nov. 14, '25
Obera bimaculate Oliv.	Raspberry cane borer	Ogdensburg	July 13, '25
Popillia japonica New.	Japanese beetle	Camden	July 8, '25
Popillia japonica New.	Japanese beetle	Lincroft	July 10, '25
Popillia japonica New.	Japanese beetle	Oaklyn	July 13, '25
Popillia japonica New.	Japanese beetle	Charleston, W. Va.	July 23, '25
Popillia japonica New.	Japanese beetle	Easton, Pa.	July 24, '25
Popillia japonica New.	Japanese beetle	Trenton	July 24, '25
Popillia japonica New.	Japanese beetle	Holmdel	July 29, '25
Popillia japonica New.	Japanese beetle	Pittstown	Aug. 1, '25
Popillia japonica New.	Japanese beetle	Bordentown	Aug. 17, '25
Popillia japonica New.	Japanese beetle	Marlton	Aug. 17, '25
Popillia japonica New.	Japanese beetle	Ringoes	Aug. 31, '25
Popillia japonica New.	Japanese beetle	New York	Sept. 2, '25
Popillia japonica New.	Japanese beetle	Gainsville, Fla.	Sept. 25, '25
Popillia japonica New.	Japanese beetle	Bloomfield	Oct. 17, '25
Popillia japonica New.	Japanese beetle	Lebanon	Oct. 17, '25
Popillia japonica New.	Japanese beetle	Brooklyn, N. Y.	Dec. 11, '25
Popillia japonica New.	Japanese beetle	Rio Grande	Dec. 18, '25

Coleoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Popillia japonica New.	Japanese beetle	Trenton	Feb. 6, '26
Popillia japonica New.	Japanese beetle	Ridgefield Park	Feb. 9, '26
Popillia japonica New.	Japanese beetle	Newark	Mar. 4, '26
Popillia japonica New.	Japanese beetle	Haddon Heights	Mar. 26, '26
Popillia japonica New.	Japanese beetle	Lebanon	Mar. 29, '26
Popillia japonica New.	Japanese beetle	Robbinsville	Mar. 30, '26
Popillia japonica New.	Japanese beetle	Bridesburg (Phila.), Pa.	Apr. 6, '26
Popillia japonica New.	Japanese beetle	Elizabeth	June 11, '26
Pityophthorus sparsus Sec.	Balsam bark beetle	Annandale	Aug. 17, '25
Plagiodera versicolora Laich.	Imported willow beetle	Ralston	Aug. 31, '25
Plagiodera versicolora Laich.	Imported willow beetle	Irvington	Oct. 6, '25
Rhynchites bicolor Fab.	Red rose beetle	Metuchen	July 9, '25
Saperda candida Fab.	Round headed apple tree borer	New York City	July 13, '25
Saperda candida Fab.	Round headed apple tree borer	Hasbrouck Heights	Aug. 4, '25
Saperda candida Fab.	Round headed apple tree borer	Pompton Plains	Aug. 4, '25
Saperda candida Fab.	Round headed apple tree borer	Merchantville	Apr. 21, '26
Saperda candida Fab.	Round headed apple tree borer	Whippany	Apr. 29, '26
Saperda candida Fab.	Round headed apple tree borer	Minotola	June 17, '26
Saperda candida Fab.	Round headed apple tree borer	East Orange	June 24, '26
Scolytus rugulosus Ratz.	Fruit tree bark beetle	Toms River	Aug. 26, '25
Scolytus rugulosus Ratz.	Fruit tree bark beetle	Hightstown	Sept. 24, '25
Strigoderma pygmaea Fab.		Cape May	July 23, '25
Systena taeniata Say	Banded flea beetle	New Brunswick	Nov. 14, '25
Tenebrioides mauretanica Linn.	Cadelle	Paterson	Sept. 23, '25
Tomicus calligraphus Gorm.	Coarse writing bark beetle	Hammonton	Sept. 23, '25
Tomicus callaigraphus Gorm.	Coarse writing bark beetle	Newton	Oct. 14, '25
Tomicus callaigraphus Gorm.	Coarse writing bark beetle	Newton	Oct. 22, '25
Tomicus callaigraphus Gorm.	Coarse writing bark beetle	Newton	Nov. 4, '25
Typophorus canellus Fab.	Strawberry root borer	Bridgeton	July 7, '25

Lepidoptera

Latin Name	*Common Name*	*Locality*	*Date*
Alabama argillacea Hubn.	Cotton moth	Gallulah, La.	Nov. 10, '25
Alsophila pometaria Pack.	Fall canker worm	Belvidere	June 23, '26
Ancylis platanana Clem.		Freehold	Aug. 26, '25
Archips argyrospila Walk.	Fruit tree leaf borer	Branchville	June 24, '26

Lepidoptera—Continued

Latin Name	Common Name	Locality	Date
Archips rosaceana Harr.	Rose leaf roller	Red Bank	May 14, '26
Argyresthia freyella Wesm.		Atlantic Highlands	July 21, '25
Bembecia marginata Harr.	Raspberry root borer	Glassboro	Sept. 8, '25
Bembecia marginata Harr.	Raspberry root borer	Washington, D. C.	June 28, '25
Carpocapsa pomonella Linn.	Codling moth	Neshanic Station	July 30, '25
Carpocapsa pomonella Linn.	Codling moth	Orange	Aug. 6, '25
Carpocapsa pomonella Linn.	Codling moth	Ocean Grove	Sept. 15, '25
Carpocapsa pomonella Linn.	Codling moth	Phillipsburg	Sept. 15, '25
Carpocapsa pomonella Linn.	Codling moth	Bridgeboro	Oct. 6, '25
Carpocapsa pomonella Linn.	Codling moth	Wenatchee, Wash.	Oct. 29, '25
Carpocapsa pomonella Linn.	Codling moth	Springdale, Ark.	Jan. 19, '26
Carpocapsa pomonella Linn.	Codling moth	Bentonville, Ark.	Feb. 25, '26
Carpocapsa pomonella Linn.	Codling moth	College Park, Md.	Feb. 26, '26
Carpocapsa pomonella Linn.	Codling moth	Dumont	Mar. 5, '26
Carpocapsa pomonella Linn.	Codling moth	Cranford	Mar. 19, '26
Carpocapsa pomonella Linn.	Codling moth	Metuchen	June 3, '26
Ceratomia catalpae Bdv.	Catalpa sphinx	Linden	July 21, '25
Ceratomia catalpae Bdv.	Catalpa sphinx	Plainfield	Sept. 2, '25
Ceratomia catalpae Bdv.	Catalpa sphinx	Westville	Mar. 5, '26
Coleophora fletcherella Fernal	Cigar case bearer	Lake Denmark, Dover	June 11, '26
Coleophora limosipennella Dup.	European elm case bearer	Westwood	May 26, '26
Coleophora malivorella Riley	Pistol case bearer	Hightstown	Apr. 21, '26
Danais plexippus Linn.	Monarch butterfly	Metuchen	Sept. 30, '25
Danais plexippus Linn.	Monarch butterfly	Elizabeth	Oct. 16, '25
Evetria buoliana Schiff	European pine shoot moth	Englewood	June 23, '26
Galleria melonella Linn.	Bee moth	Robbinsville	Jan. 26, '26
Heliothis obsoleta Hon.	Corn ear worm	Little Falls	July 13, '25
Heliothis obsoleta Hon.	Corn ear worm	Wennonah	July 24, '25
Heliothis obsoleta Fab.	Corn ear worm	Morristown	Sept. 16, '25
Heliothis obsoleta Fab.	Corn ear worm	Titusville	Sept. 30, '25
Heliothis obsoleta Fab.	Corn ear worm	Clifton	Oct. 1, '25
Heliothis obsoleta Fab.	Corn ear worm	New York	Oct. 1, '25
Heliothis obsoleta Fab.	Corn ear worm	Elizabeth	Jan. 7, '26
Heliothis obsoleta Fab.	Corn ear worm	Freehold	Apr. 7, '26

Lepidoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Heliothis obsoleta Fab.	Corn ear worm	New Gretna	June 11, '26
Heliothis obsoleta Fab.	Corn ear worm	Berlin	June 18, '26
Hemerophila pariana Clerck	Apple thorn skeletonizer	Little York	Aug. 4, '25
Hemerophila pariana Clerck	Apple thorn skeletonizer	Woodbury	Aug. 27, '25
Hemerophila pariana Clerck	Apple thorn skeletonizer	Newark	Sept. 24, '25
Hemerophila pariana Clerck	Apple thorn skeletonizer	Washington	Sept. 30, '25
Hemaris thysbe Fab.	Humming bird clear wing	Jamesburg	Aug. 14, '25
Heterophleps trigutaria H. S.	Measuring worm	East Orange	Sept. 30, '25
Hyphantria cunea Dree.	Fall web worm	Plainfield	Aug. 14, '25
Hyphantria cunea Dree.	Fall web worm	Woodbury	Aug. 27, '25
Hyphantria cunea Dree.	Fall web worm	South Amboy	Sept. 2, '25
Laspeyresia molesta Busk.	Oriental peach moth	Paterson	Aug. 7, '25
Laspeyresia molesta Busk.	Oriental peach moth	Brookside	Aug. 21, '25
Laspeyresia molesta Busk.	Oriental peach moth	Lambertville	Oct. 23, '25
Laspeyresia molesta Busk.	Oriental peach moth	Westfield	Nov. 6, '25
Laspeyresia molesta Busk.	Oriental peach moth	Orange	Dec. 5, '25
Laspeyresia molesta Busk.	Oriental peach moth	Greensboro	Jan. 9, '26
Laspeyresia molesta Busk.	Oriental peach moth	Ontario, Canada	Jan. 9, '26
Laspeyresia molesta Busk.	Oriental peach moth	Moorestown	Feb. 6, '26
Laspeyresia molesta Busk.	Oriental peach moth	Freehold	Apr. 7, '26
Laspeyresia molesta Busk.	Oriental peach moth	Merchantville	Apr. 21, '26
Laspeyresia molesta Busk.	Oriental peach moth	Highland, N. Y.	Apr. 28, '26
Laspeyresia molesta Busk.	Oriental peach moth	Brookside	Apr. 30, '26
Laspeyresia molesta Busk.	Oriental peach moth	Camden	May 21, '26
Laphygma frugiparda Sxa.	Fall army worm	Trenton	June 24, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Union	Sept. 8, '25
Malacosoma americana Fab.	American apple tree tent caterpillar	Morristown	Sept. 21, '25
Malacosoma americana Fab.	American apple tree tent caterpillar	Newark	July 13, '25
Malacosoma americana Fab.	American apple tree tent caterpillar	Sussex	July 24, '25
Malacosoma americana Fab.	American apple tree tent caterpillar	Brielle	July 30, '25
Malacosoma americana Fab.	American apple tree tent caterpillar	Orange	Dec. 5, 25
Malacosoma americana Fab.	American apple tree tent caterpillar	Metuchen	Mar. 1, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Hackensack	Mar. 8, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Keyport	May 14, '26

Lepidoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Malacosoma americana Fab.	American apple tree tent caterpillar	Port Reading	May 20, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Highland Park	May 26, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Red Bank	May 26, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Keyport	May 28, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Locust	May 28, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Deal	June 3, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Rahway	June 3, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	Hawthorne	June 9, '26
Malacosoma americana Fab.	American apple tree tent caterpillar	New York City	June 9, '26
Malacosoma disstria Hbn.	Forest tent caterpillar	Woodbury	June 23, '26
Mamestra picta Harr.	Zebra caterpillar	Newark	Sept. 4, '25
Melittia satyriniformis Hubn.	Squash vine borer	Lebanon	July 25, '25
Melittia satyriniformis Hubn.	Squash vine borer	Branchville	Sept. 22, '25
Noctuidae	Cut worm	Grand Rapids, Mich.	July 3, '25
Noctuidae	Cut worm	Cape May	Apr. 23, '26
Noctuidae	Cut worm	Creamridge	May 21, '26
Noctuidae	Cut worm	Pleasantville	May 21, '26
Noctuidae	Cut worm	Belleville	May 28, '26
Noctuidae	Cut worm	Elizabeth	June 3, '26
Noctuidae	Cut worm	Lakewood	June 3, '26
Noctuidae	Cut worm	Metuchen	June 3, '26
Noctuidae	Cut worm	New Brunswick	June 3, '26
Noctuidae	Cut worm	Rochelle Park	June 3, '26
Noctuidae	Cut worm	Belleville	June 9, '26
Noctuidae	Cut worm	East Orange	June 9, '26
Noctuidae	Cut worm	Hawthorne	June 9, '26
Noctuidae	Cut worm	Perth Amboy	June 18, '26
Noctuidae	Cut worm	Fort Lee	June 24, '26
Noctuidae	Cut worm	Westfield	June 24, '26
Olethreutes hebesana Walk.		Upper Montclair	June 3, '26
Oxyptilus periscelidactylus Fitch	Grape plume moth	New Brunswick	June 18, '26
Paleacrita vernata Peck	Spring canker worm	Dover	June 11, '26
Pandemis limitata Rob.		Trenton	July 27, '25
Pandemis limitata Rob.		Branchville	June 15, '26
Papaipema nitela Gn.	Common stalk borer	Cranford	July 14, '25

Lepidoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Papaipema purpurifascia G. & R.	Columbine root borer	Morristown	June 18, '26
Papilio polyxeness Fab.	Eastern swallow tail	Westfield	July 29, '25
Papilio turnus Linn.	Tiger swallow tail	Morristown	Oct. 23, '25
Papilio turnus Linn.	Tiger swallow tail	New Brunswick	Nov. 14, '25
Paragrotis tesselata Harris	Striped cut worm	Vineland	May 5, '26
Phlegethontius carolina Linn.	Tomato horn worm	Elizabeth	Oct. 16, '25
Phthorimaea operculella Zell.	Potato tuber moth	Freehold	Nov. 14, '25
Phyllonoryter betulivora Wlsm.	Birch leave miner	Maplewood	July 21, '25
Prionoxystus robiniae Peck	Carpenter worm	Riverdale	Sept. 4, '25
Prionoxystus robiniae Peck	Carpenter worm	Hackensack	Oct. 28, '25
Prionoxystus robiniae Peck	Carpenter worm	Camden	Dec. 8, '25
Prionoxystus robiniae Peck	Carpenter worm	Haddonfield	Dec. 30, '25
Prionoxystus robiniae Peck	Carpenter worm	Perth Amboy	May 28, '26
Pyrausta nubilalis Hubn.	European corn borer	Gibbsboro	Jan. 26, '26
Sanninoidea exitiosa Say.	Peach tree borer	Newark	Aug. 27, '25
Sanninoidea exitiosa Say.	Peach tree borer	Bridgeville, Del.	Sept. 15, '25
Sanninoidea exitiosa Say.	Peach tree borer	Lyndhurst	Sept. 15, '25
Sanninoidea exitiosa Say.	Peach tree borer	Hightstown	Sept. 24, '25
Sanninoidea exitiosa Say.	Peach tree borer	Tabor	Nov. 14, '25
Sanninoidea exitiosa Say.	Peach tree borer	Eatontown	Jan. 18, '26
Sanninoidea exitiosa Say.	Peach tree borer	Bridgeton	Jan. 26, '26
Sanninoidea exitiosa Say.	Peach tree borer	Cape May	Jan. 26, '26
Sanninoidea exitiosa Say.	Peach tree borer	Morrisville	Mar. 10, '26
Sanninoidea exitiosa Say.	Peach tree borer	Trenton	Apr. 6, '26
Sanninoidea exitiosa Say.	Peach tree borer	Long Island, N. Y.	Apr. 7, '26
Sanninoidea exitiosa Say.	Peach tree borer	**Whippany**	Apr. 29, '26
Sanninoidea exitiosa Say.	Peach tree borer	Skilman	June 23, '26
Sanninoidea exitiosa Say.	Peach tree borer	Philadelphia	June 24, '26
Schizura concinna Sxa.	Red humped apple caterpillar	Madison	Aug. 6, '25
Sesia acerni Clem.	Common maple borer	Gladstone	Aug. 17, '25
Sesia acerni Clem.	Common maple borer	Woodbury	Aug. 27, '25
Sesia rhododendri Beut.	Rhododendron clear wing	Plainfield	June 11, '26
Sibine stimulea Clem.	Saddle back caterpillar	Atco	Aug. 6, '25
Sibine stimulea Clem.	Saddle back caterpillar	Sewell	Aug. 6, '25
Sibine stimulea Clem.	Saddle back caterpillar	Woodstown	Aug. 11, '25

Lepidoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Sitotroga cerealella Oliv.	Angoumois grain moth	Hackettstown	June 3, '26
Sphecodina abbstii Swains.	Abbots sphinx	Freehold	July 21, '25
Sphecodina abbstii Swains.	Abbots sphinx	Lebanon	July 21, '25
Sphinx drupiferarum Sm.		Belvidere	July 23, '25
Tinea pellionella Linn.	Cloth moth	Woodbury	Aug. 17, '25
Tineola biselliella Hum.	Webbing cloth moth	Red Bank	Nov. 19, '25
Tineola biselliella Zell.	Webbing cloth moth	Plainfield	May 28, '26
Xylophasia arctica Boisd.	Yellow-headed cutworm	Morristown	July 2, '25
Zeuzera pyrina Linn.	Wood leopard moth	New Brunswick	May 11, '26
Zeuzera pyrina Linn.	Wood leopard moth	Camden	May 21, '26
	Hymenoptera		
Amphibolips inanis O. S.	Gall wasp	Matawan	Aug. 10, '25
Apanteles sp.	Parasitic insect	Morristown	May 28, '26
Apis mellifera Linn.	Honey bee	Helper, Utah	July 9, '25
Apis mellifera Linn.	Honey bee	Basking Ridge	July 13, '25
Apis mellifera Linn.	Honey bee	Quebec, Canada	July 22, '25
Apis mellifera Linn.	Honey bee	Cranford	July 27, '25
Apis mellifera Linn.	Honey bee	New York	July 27, '25
Apis mellifera Linn.	Honey bee	Ralston	July 27, '25
Apis mellifera Linn.	Honey bee	Ramsey	July 28, '25
Apis mellifera Linn.	Honey bee	Jamesburg	Aug. 4, '25
Apis mellifera Linn.	Honey bee	Robbinsville	Oct. 1, '25
Apis mellifera Linn.	Honey bee	Trenton	Oct. 5, '25
Apis mellifera Linn.	Honey bee	Bordentown	Oct. 21, '25
Apis mellifera Linn.	Honey bee	Overland Park. Kans.	Oct. 26, '25
Apis mellifera Linn.	Honey bee	Ft. Collins, Colo.	Oct. 30. '25
Apis mellifera Linn.	Honey bee	Morristown	Nov. 25, '25
Apis mellifera Linn.	Honey bee	New York	Dec. 4, '25
Apis mellifera Linn.	Honey bee	Neptune	Dec. 11, '25
Apis mellifera Linn.	Honey bee	Long Valley	Dec. 17, '25
Apis mellifera Linn.	Honey bee	Ft. Collins, Colo.	Jan. 7, '26
Apis mellifera Linn.	Honey bee	Bound Brook	Feb. 4, '26
Apis mellifera Linn.	Honey bee	Camden	Feb. 5, '26
Apis mellifera Linn.	Honey bee	Mt. Holly	Feb. 5, '26
Apis mellifera Linn.	Honey bee	Trenton	Feb. 27, '26

Hymenoptera—Continued

Latin Name	Common Name	Locality	Date
Apis mellifera Linn.	Honey bee	Elyria, Ohio	Mar. 3, '26
Apis mellifera Linn.	Honey bee	Browns Mills	Mar. 11, '26
Apis mellifera Linn.	Honey bee	Milford	Mar. 11, '26
Apis mellifera Linn.	Honey bee	Clayton	Mar. 29, '26
Apis mellifera Linn.	Honey bee	Clayton	May 10, '26
Apis mellifera Linn.	Honey bee	Newark	May 10, '26
Apis mellifera Linn.	Honey bee	Short Hill	May 10, '26
Apis mellifera Linn.	Honey bee	New Brunswick	May 11, '26
Apis mellifera Linn.	Honey bee	New Brunswick	May 11, '26
Apis mellifera Linn.	Honey bee	Metuchen	May 11, '26
Apis mellifera Linn.	Honey bee	Bloomfield	May 13, '26
Apis mellifera Linn.	Honey bee	Pemberton	May 18, '26
Apis mellifera Linn.	Honey bee	Lebanon	May 26, '26
Apis mellifera Linn.	Honey bee	Clinton	June 24, '26
Apis mellifera Linn.	Honey bee	Bell Mead	June 28, '26
Camponotus pennsylvanicus De. G.	Common black carpenter ant	Englewood	Sept. 24, '25
Camponotus pennsylvanicus De. G.	Common black carpenter ant	Somerville	May 20, '26
Camponotus pennsylvanicus De. G.	Common black carpenter ant	Plainfield	June 9, '26
Chrysis coeruleans Fab.	Cuckoo bee	New Brunswick	Aug. 10, '25
Cynipidae sp.	Gall wasp	Upper Montclair	Nov. 14, '25
Diprion simile Hartig	European pine saw fly	Plainfield	Aug. 6, '25
Endelomyia aethiops Fab.		Murray Hill	July 23, '25
Eriocampoides limacina Ratz.	Pear slug	Fort Lee	July 30, '25
Eriocampoides limacina Ratz.	Pear slug	Millville	July 30, '25
Eriocampoides limacina Ratz.	Pear slug	Audabon	Aug. 5, '25
Eriocampoides limacina Ratz.	Pear slug	Westville	Mar. 5, '26
Eriocampoides limacina Ratz.	Pear slug	Ridgefield Park	June 23, '26
Fenusa pumila Klug.	European birch leaf miner	Arsendtville, Pa.	Aug. 14, '25
Fenusa pumila Klug.	European birch leaf miner	East Orange	June 24, '26
Fenusa pumila Klug.	European birch leaf miner	East Orange	June 25, '26
Formicidae	Ant	Orange	July 21, '25
Formicidae	Ant	Bloomfield	July 28, '25
Janus integer Nort.	Willow shoot sawfly	New Brunswick	July 21, '25
Megarhyssa lunator Fab.	Long tailed Ichneumon	East Orange	Sept. 30, '25
Monomorium minutum May	Small black household ant	Princeton	June 17, '26

Hymenoptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Monomorium minutum May	Small black household ant	Elizabeth	June 24, '26
Monomorium pharaonis Linn.	Red pharaons ant	Collingswood	July 3, '25
Monomorium pharaonis Linn.	Red pharaons ant	East Orange	Sept. 19, '25
Monomorium pharaonis Linn.	Red pharaons ant	Vineland	Nov. 18, '25
Monomorium pharaonis Linn.	Red pharaons ant	Flemington	June 4, '26
Pemphredon **sp.**	Digger wasp	Woodbury	Aug. 27, '25
Pemphredon inornatus Say.		Mt. Holly	Mar. 30, '26
Rhodites bicolor Harr.	Spiny rose gall	Blairstown	Mar. 30, '26
Rhodites bicolor Harr.	Spiny rose gall	Toms River	June 29, '26
Scolia dubia Say.	Digger wasp	Camden	Sept. 19, '25
Sphecius speciosus Dru.	Cicada killer	Oldwick	July 30, '25
Sphecius speciosus Dru.	Cicada killer	New York	Aug. 8, '25
Sphecius speciosus Dru.	Cicada killer	New York City	Aug. 14, '25
Sphecius speciosus Dru.	Cicada killer	New York	Aug. 17, '25
Tetramorium caespitum Linn.	Lawn ant	East Orange	Mar. 30, '26
Tetramorium caespitum Linn.	Lawn ant	Toms River	Apr. 20, '26
Tetramorium caespitum Linn.	Lawn ant	Trenton	May 11, '26
Tetramorium caespitum Linn.	Lawn ant	Flemington	May 21, '26
Tetramorium caespitum Linn.	Lawn ant	Hasbrouck Heights	May 26, '26
Tetramorium caespitum Linn.	Lawn ant	Camden	May 14, '26
Tetramorium caespitum Linn.	Lawn ant	Somerville	May 14, '26
Tetramorium caespitum Linn.	Lawn ant	Trenton	May 28, '26
Tetramorium caespitum Linn.	Lawn ant	South Orange	June 14, '26
Tetramorium caespitum Linn.	Lawn ant	Elizabeth	June 17, '26
Tetramorium caespitum Linn.	Lawn ant	Philadelphia, Pa.	June 18, '26
Vespa crabro Linn.	European hornet	Eatontown	Aug. 31, '25
Vespa crabro Linn.	European hornet	Newark	Feb. 11, '26
Vespa germanica Fab.	Yellow Jacket	Morristown	Oct. 23, '25
Vespa germanica Fab.	Yellow Jacket	Red Bank	Oct. 23, '25
	Siphonoptera		
Ctenocephalus canis Curt.	Common dog flea	Sound Beach, Conn.	July 23, '25
Ctenocephalus canis Curt.	Common dog flea	Irvington	July 28, '25
Ctenocephalus canis Curt.	Common dog flea	Montclair	July 29, '25
Ctenocephalus canis Curt.	Common dog flea	Bound Brook	Aug. 14, '25
Ctenocephalus canis Curt.	Common dog flea	Passaic	Aug. 14, '25

Siphonoptera—Continued

Common Name	Latin Name	Locality	Date
Ctenocephalus canis Curt.	Common dog flea	Vineland	Oct. 1, '25
Ctenocephalus canis Curt.	Common dog flea	Toms River	Feb. 2, '26
Ctenocephalus canis Curt.	Common dog flea	New Brunswick	Feb. 18, '26
	Diptera		
Aedes sylvestris Theob.	Fresh water swamp mosquito	Chicago, Ill.	July 27, '25
Aedes trivittatus cog.	Three striped mosquito	Chicago, Ill.	July 27, '25
Agromyza laterella Zell.	Leaf miner	Summit	Aug. 14, '25
Anopheles crucians Wied.	Daylight anopheles	Jersey City	June 9, '26
Chironomidae		Hackensack	July ,1 '25
Culex pipiens Linn.	House mosquito	Trenton	Nov. 18, '25
Culicidae	Mosquito	Princeton	July 13, '25
Culicidae	Mosquito	Gulfport, Miss.	July 23, '25
Culicidae	Mosquito	Jersey City	July 29, '25
Culicidae	Mosquito	Elizabeth	Sept. 8, '25
Culicidae	Mosquito	Hackensack	Sept. 11, '25
Culicidae	Mosquito	Paterson	Sept. 11, '25
Culicidae	Mosquito	Pass Christian, Miss.	Sept. 24, '25
Culicidae	Mosquito	Gulfport, Miss.	Oct. 20, '25
Culicidae	Mosquito	Baltimore, Md.	Oct. 29, '25
Culicidae	Mosquito	Brooklyn	Nov. 5, '25
Culicidae	Mosquito	Cornwall-on-Hudson	Nov. 10, '25
Culicidae	Mosquito	Jefferson City, Mo.	Dec. 4, '25
Culicidae	Mosquito	Russia	Dec. 7, '25
Culicidae	Mosquito	Asbury Park	Dec. 18, '25
Culicidae	Mosquito	Toms River	Feb. 11, '26
Culicidae	Mosquito	Calais, Maine	Mar. 2, '26
Culicidae	Mosquito	Millington	Mar. 2, '26
Culicidae	Mosquito	White Plains	Mar. 2, '26
Culicidae	Mosquito	Boston, Mass.	Mar. 22, '26
Culicidae	Mosquito	Chicago, Ill.	Mar. 22, '26
Culicidae	Mosquito	Essex, Conn.	Mar. 22, '26
Culicidae	Mosquito	New York City	Mar. 22, '26
Culicidae	Mosquito	Ottawa, Canada	Mar. 22, '26
Culicidae	Mosquito	Merced, Calif.	Mar. 23, '26
Culicidae	Mosquito	Seattle, Wash.	Mar. 23, '26

Diptera—Continued

Latin Name	*Common Name*	*Locality*	*Date*
Culicidae	Mosquito	Clemson Coll., S. C.	Mar. 30, '26
Culicidae	Mosquito	Philadelphia, Pa.	Mar. 30, '26
Culicidae	Mosquito	Rochelle Park	Apr. 16, '26
Culicidae	Mosquito	Union City	Apr. 17, '26
Diarthronomyia hypogoea F. Lowe	Chrysanthemum midge	Wye Kent, Eng.	Nov. 4, '25
Diarthronomyia hypogoea F. Lowe	Chrysanthemum midge	Yakima, Wash.	Dec. 5, '25
Diarthronomyia hypagoea H. Lee	Chrysanthemum gall midge	Iona	Mar. 30, '26
Gastrophilus equi Fab.	Horse bot fly	Trenton	Sept. 21, '25
Itonida catalpae Comst.	Catalpa midge	New Brunswick	Sept. 8, '25
Monarthropalpus buxi Lab.	Boxwood leaf miner	Woodbury	July 8, '25
Monarthropalpus buxi Lab.	Boxwood leaf miner	Wye. Kent, Eng.	Nov. 4, '25
Monarthropalpus buxi Lab.	Boxwood leaf miner	Orono, Maine	Nov. 14, '25
Monarthropalpus buxi Lab.	Boxwood leaf miner	Syracuse, N. Y.	Apr. 14, '26
Musca domestica Linn.	House fly	Clinton	July 23, '25
Musca domestica Linn.	House fly	Newark	Dec. 14, '25
Musca domestica Linn.	House fly	Catskill, N. Y.	Mar. 10, '26
Pegomyia brassicae Bouche	Cabbage maggot	Paterson	May 4, '26
Pegomyia brassicae Bouche	Cabbage maggot	Ramsey	June 17, '26
Pegomyia brassicae Bouche	Cabbage maggot	New Monmouth	Jan. 13, '26
Pegomyia brassicae Bouche	Cabbage maggot	Haddonfield	May 11, '26
Pegomyia brassicae Bouche	Cabbage maggot	Newark	June 18, '26
Phorbia ceparum Meig.	Common onion maggot	Woodbury	Feb. 24, '25
Phorbia ceparum Meig.	Common onion maggot	Hainesbury	June 18, '26
Phorbia fusciceps Zett.	Seed corn maggot	Woodbury	June 9, '26
Phorbia fusciceps Zett.	Seed corn maggot	Paterson	June 11, '26
Rhagoletis pomanella Walsh	Apple maggot	Pattenburg	Sept. 30, '25
Rhagoletis pomanella Walsh	Apple maggot	Cape May	Mar. 30, '26
Rhagoletis pomanella Walsh	Apple maggot	Northport	June 17, '26
Rhagoletis suavis Loew.	Walnut husk maggot	Woodstown	Oct. 16, '25
Rhagoletis suavis Loew.	Walnut husk maggot	Swedesboro	Oct. 17, '25
Rhagoletis suavis Loew.	Walnut husk maggot	Bordentown	May 29, '26
Sciara multiseta Felt.	Mushroom maggot	Mt. Holly	May 28, '26
Spagostylum simson Fab.	Bee-fly	Jamesburg	Aug. 14, '25
Spilographa electa Say.	Pepper maggot	Riverside	July 13, '25
Spilographa electa Say.	Pepper maggot	Woodbury	Feb. 24, '26

INSECTS OF THE YEAR

Under this heading it is desired to submit some data supplementary to the correspondence list which precedes:

The European Red Mite. The European red mite (*Paratetranychus pilosus*) has exhibited a state-wide distribution during the past year and consequently the ordinary delayed dormant lime-sulfur and nicotine spray on apple has been almost entirely eliminated in favor of miscible oils and oil emulsions.

Apple Aphis. Apple Aphis (*Aphis pomi, Aphis sorbi, Aphis avenae*) eggs, during the winter of 1925-1926, were apparently as scarce as the European red mite eggs were abundant. With the elimination of the lime-sulfur nicotine spray in favor of mite egg killing oils at the delayed dormant time, a considerable infestation of the rosy aphis made its appearance in the spring and early summer of 1926, doing, in some instances, a considerable amount of harm. Taking the state as a whole, however, it can be said that the apple aphis has done little economic damage this year.

Green Peach Aphis. The green peach aphis (*Myzus persicae*), which was so numerous last year, has, during the spring of 1926, been almost entirely absent.

The Apple Tent Caterpillar. The apple tent caterpillar (*Malacosma americana*) has continued in as great abundance in the spring of 1926 as for several years past and has occasioned many inquiries and considerable disturbance of mind. This insect is a native insect, devotes its attention in this state to wild cherry and neglected apple orchards, and is not an economic factor in food production. Its principal economic importnace seems to lie in the fact that its large webs along the roadsides and in other conspicuous places excite interest and alarm among our people. A number of local campaigns for its destruction have been run, principally through the medium of having school children and boy scouts pick the egg masses in the dormant season. The results of these campaigns have been very striking.

The Japanese Beetle. The Japanese beetle (*Popillia japonica*) has continued its spread during the summer season of 1925, although it did not cover as great additional new territory as was expected. It seems that when the occupied area reaches a certain relation to the heavily infested area the spread of the beetle becomes slow.

The Codling Moth. The codling moth (*Carpocapsa pomonella*) has shown about the same vigor this year as has characterized its activities for the past several years. There seems to be no evidence at this time of increasing parasitism. Wherever control measures for this insect are sufficiently faithfully practiced, injury by it is reduced to a negligible point.

The Oriental Peach Moth. The oriental peach moth (*Laspeyresia molesta*) did much less injury last season than in the preceding season, owing to the great activity of certain parasites, and its beginnings in the season of 1926 indicated that a similar condition will be found to obtain by the close of the summer season of 1926.

INVESTIGATIONS

Climate and Insect Investigation

Introduction

In the following brief discussion the entomologist has tried to set forth some general conclusions relative to the relation existing between climate and insect activity. Such controversial points as the thermal constant and threshold of development have been left out. Climatic factors will be treated as follows: temperature, atmospheric moisture, sunlight, barometric pressure, and wind movements.

Temperature

Temperature measured from the standpoint of modification, which it is capable of making in the rate of insect metabolism, stands out by far as the most important factor of climate. As has been shown by Bachmetjew and others, the effects of temperature range from a death point of low temperature through a range of quiescence resembling death, through a range of increasing metabolism to a point of maximum speed of metabolism, through a range of decreasing metabolism, through another range of quiescence resembling death to a death point of high temperature.

It has been shown by various workers that different species of insects are differently affected by the same ranges of temperature. Because of this fact, temperature forms the general limiting factor not only in the seasonal distribution but also in the geographical distribution of insects. Thus, in general, every insect species has its northern or southern low temperature limit and approximately tropical or subtropical high-temperature limit. The tropical or subtropical high-temperature limit is, however, only approximate because the temperatures of the tropics are not necessarily lethal.

Thus far only the direct effect of the temperature factor of climate has been considered. Indirectly, through limiting the distribution of food plants and through affecting the relation existing between insect hosts and their parasitic and predaceous enemies, temperature materially affects the distribution and abundance of insect species.

The exact mechanism by which temperature produces its effects upon insects is not well understood. In dealing with direct effects, insofar as they relate to increase or decrease of metabolic rate, their similarity to temperature effects on chemical reaction has led some investigators to attribute temperature effects on the metabolic rate of insects to increased or decreased speed of chemical reaction. This may be true or the observed effects may merely indicate that chemical reaction is sufficiently dominant to give that impression. High temperatures are thought to kill through coagulation of the proteins. Again this may or may not be true because the conclusion is drawn from analogy. Low temperature lethal effects have been thought to be due to rupture of tissue through the actual congealing of the body fluids, This conclusion may or may not be true because it is drawn from analogy.

The mechanism employed in producing indirect temperature effects upon insect species is the same as that producing direct effects, because it is simply the difference in the effect of the same temperature ranges upon host, parasite, and source of food. Without doubt, temperature has a far more important bearing upon the relation existing between parasite and host than upon the relations between host and predator or between insect and food plant. The most important species of insects living as parasites on other insects belong to the *Diptera* and *Hymenoptera* and members of these orders are active within a much narrower temperature range than are their hosts. In such cases temperature becomes the primary factor governing this relationship and determining when and to what extent the parasitic form attacks the host. Fungi parasitic upon insects are likewise largely limited by temperature, but of a range much lower than that affecting the parasitic *Diptera* and *Hymenoptera.*

Atmospheric Moisture

Atmospheric moisture affects insect life both directly and indirectly, but to a much less extent than temperature. Like temperature, there is a lethal low moisture, a lethal high moisture and a wide range between, covering a zone in which insect activity goes forward. Insects which are able to imbibe water show within the living range far less response to varying percentages of relative humidity than those which live upon dry foods and must either make their own water or absorb it from the air.

Without doubt, low atmospheric moisture directly limits both the seasonal and the geographic distribution of many insect species and, without doubt, high atmospheric moisture limits the distribution of many species. High atmospheric moisture affects its limitations of distribution largely through the encouragement of parasitic entomogenous fungi and to some extent bacteria.

Indirect effects of atmospheric moisture are brought about through the curtailing of the range of food plants (low atmsopheric moisture) and through encouragement of parasitic entomogenous fungi (high atmospheric moisture).

The mechanism underlying direct atmospheric moisture effects is not explained. Low atmospheric moisture is thought to operate by removal of water from the body fluids, producing increased concentration which, when great enough, affects the distribution of the insect through prevention of insect activity. It is well known, however, that certain species can, in certain stages, withstand this condition for a long time. It is thought that there is an optimum dilution of the body water which differs for different stages of the same insect and for different insects, and that metabolism proceeds slowly or rapidly, depending upon the relation of dilution to the specific optimum. It is thought that high atmospheric moisture affects insects primarily through the encouragement of parasitic entomogenous fungi and secondarily through preventing the elimination of excess body water.

Much further fundamental study must be made before certainty can take the place of supposition.

Precipitated atmospheric moisture limits the activities of many species and that result is due, apparently, to mechanical effects.

Sunlight

Sunlight, doubtless, affects insect activities to a very large extent, but with present knowledge its effects are not nearly as well known as temperature or even atmospheric moisture. It has not even been demonstrated where sunlight has its lethal high, lethal low and active range between. Its effects are largely transformed into heat and appear as temperature effects. In view of the well-known stimulative effect of the actinic rays of sunlight, it seems very probable that the metabolic curve may be similiar to that of temperature and moisture.

Indirectly sunlight affects the distribution of insects through limiting food plants and possibly by destroying parasitic fungi and bacteria.

Barometric Pressure

Barometric pressure, save insofar as it affects wind movements, seems to be of little, if any, importance. Investigations of this factor, however, are too limited to serve as a basis for any hard and fast conclusions.

Wind Movements

Wind movements affect the activities and distribution of some species largely. Nearly all aerial insects stick close to shelter when winds are strong. Some species fly with low-speed winds and others against low-speed winds. A few species are moved for long distances by long continued high-speed winds.

Climate in General

The relation of climatic factors to insect periodicity, if anything of the sort really exists, has not been uncovered by any adequate investigation. With present data it cannot be said that any such relationship has been demonstrated.

The economic value of an understanding of the relation of climatic factors to insect activity lies in the resultant ability to forecast insect outbreaks within the present area of distribution, to forecast distribution of species beyond their present range, when the great material barriers of oceans and mountains have been overcome, and in a betterment of knowledge in the methods of using artificial and natural measures of control.

A Study of the Body Moisture, Fats and Nitrogen Occurring in the Apple Tent Caterpillar *(Malacasoma americana)* Throughout Its Life Cycle

As indicated in the annual report for the year ending June 30, 1925, this study was undertaken from the standpoint of the water content of the body fluid, but incidentally was extended to include the fat and nitrogen. Two papers by Dr. Rudolfs on the data are now in press. An attempt will be made here to present a short summary.

The moisture content of the eggs, beginning about 48.5 per cent, decreased until hatching, when it reached 39.4 per cent. From this point it rose rapidly, reaching 68.5 per cent six days after hatching and 85.1 per cent at the close of the second instar. It remained at about this figure until pupation when it dropped to 71.0. The moisture still further decreased when the adults appeared and then amounted to about 60.0 per cent.

The fat content of the eggs at deposition was about 9.0 per cent, and decreased until hatching when it amounted to 0.66 per cent.

From this point it rose until, at the end of the second instar, it was about 5.85 per cent. From that point the fat content rose slowly until the caterpillars were about 34 mm. (1⅓ inch) long, when it was 8.04 per cent. When the larvae were ready to pupate the fat content was about 18.71 per cent. In the pupae it was about 28.82 per cent, and in the fresh adults 26.1 per cent.

Nitrogen appeared both in the egg shells and in the frothy covering of the egg mass. This covering contained 8.0 to 8.4 per cent water, about 16 per cent nitrogen and no fat. The nitrogen content of the unhatched but recently fully formed larvae ranged between 9.0 and 10.0 per cent. Nitrogen rose slowly and rather gradually to time of hatching, when it was about 15.13 per cent. From that point it diminished slowly until in the pupa it was about 8.26 per cent. In the fresh adult it was about 9.03 per cent.

In summarizing the above data it may be said that the water content of the egg decreased 7.1 per cent, after hatching rose 45.7 per cent, and remained at that point until pupation when it fell 14.1 per cent. In the adult it fell 11.0 per cent more. These facts serve to indicate that body water requqirements for the Apple Tent Caterpillar are about 40± per cent greater in the larvel than in the egg stage, 26± per cent greater in the pupal stage than in the egg stage, and 15± per cent greater in the adult stage than in the egg stage.

Relative to the fat content, it should be pointed out that the fat in the egg is almost entirely consumed, that fat is built up during the larval life and with especial rapidity as completion of growth approaches, that the process of pupation and formation of the adult does not exhaust it but leaves a supply to the adult from which energy can be drawn for activities necessary to egg maturation and the equipping of the eggs with a reserve food supply.

Nitrogen, representing the proteins, bears about the same relation to body weight throughout the cycle from egg to adult, except at the time of hatching when nearly all stored food has been used and fresh food has not yet become available. A small increase in the percentage of nitrogen appears in the adult which may be necessary for the formation of egg shells and cover.

Orchard Insect Investigations

Codling Moth

Timing of Sprays for Control of the Side-Worms of the Codling Moth

This is a subject to which a large amount of attention has been given in various parts of the United States. Some years ago, after investigation, the codling moth cage was adopted as the most practical method of determining the time when the application for side-worms of each of the broods should begin.

One hundred apparently healthy hibernating larvae of the codling moth were collected and placed in a screen-wire-bottom wooden box, which was painted white and hung to a limb of an average apple tree in what was considered an orchard typical of the region concerned. Each larva was enclosed in a small glass vial plugged with rolled cotton. At least one of these cages, and not infrequently more, were maintained within the limits of a single county under the care of the county agricultural agent. It was found that there always came a time when the curve of emergence exhibited a sudden and large upward jump. Promptly when this jump made its appearance the growers were advised to begin spraying for the side-worms of the codling moth.

Descending adult larvae of the first brood of codling moth were collected from burlap bands each in its own glass vial, plugged with rolled cotton and placed, as before, in the codling moth cage. Soon after the emergence of the second brood of moths began, evidences that a large upward jump in the curve was due would appear, and as soon as these evidences were detected the growers were advised to make spray application for the side-worms of the second brood.

This scheme of timing seems to have resulted in the establishment of pretty satisfactory control of the side-worms of the codling moth, but the finding of codling moth adults in bait pans used for catching adults of the oriental peach moth led us to wonder whether the bait pans might not be used as an indicator. The work of Glenn on the codling moth thermal constant in the state of Illinois also excited our interest. It was decided to make comparative tests of the three methods. Accordingly stations for this purpose were established at Pattenburg, latitude 40°-38' north, altitude 700 feet above the sea; New Brunswick, latitude 40°-29′ north and altitude 110 feet; Riverton, latitude 40°-1′ north and altitude 15 feet; Glassboro, 39°-43′ north and altitude 130 feet; and Bridgeton, latitude 39°-56′ north and altitude 90 feet. We should like to have included a station in Monmouth County, but the facilities at our command were not sufficient. At each of these stations a tested maximum and minimum thermometer was established, and a codling moth cage, containing 400 larvae, was placed. At Glassboro two codling moth cages were placed and ten bait pans were installed. The bait material used was practically the same as that employed for the oriental peach moth and consisted of three parts by volume of "Black Strap" molasses and one part by volume of water. Yeast was added to each pan. The larvae in each of the boxes, except the second one at Glassboro, were drawn from collections made at two different times. One 200-component was drawn from collections made in September, 1925. A second 200-component was drawn from a collection made in January, 1926. In all of these cases the collections were made at Glassboro, brought to New Brunswick and left in the screened outdoor insectary for storage until the time they were placed in the boxes and carried to each of the different stations. The second box at Glassboro contained over 400 larvae which were collected in February from the orchard in which the box was placed. Just as soon as the material was collected and placed in the box it was hung on a tree in the orchard.

TABLE 1
Codling Moth Cage Record, 1926

DATE	EMERGENCE																						
	Pattenburg				New Brunswick				Riverton				Glassboro								Bridgeton			
													Repp				Mecouch							
	Found		Accum.		Found		Accum.		Found		Accum.		Found		Accum.		Found		Accum.		Found		Accum.	
	R*	B	R	B	R	B	R	B	R	B	R	B	R	B	R	B	R	B	R	B	R	B	R	B
5/18					0	0																		
19									0	0			0				0	0			0	0		
20	0	0																						
28					0	2	0	2					62		62		1	17	1	17	1	17	1	17
29									0	1	0	1												
6/1	0	0																						
4													172		max. 234		29	41	max. 30	58	18	55	max. 19	72
5									9	38	9	39												
6					0	3	0	5																
8	2	9	2	9																				
11									15	35	max. 24	74	38		272		23	12	53	70	27	15	46	87
12					18	27	18	32																
16	33	68	max. 35	77																				
18									21	20	45	94	46		318		15	10	68	80	25	20	71	107
19					15	37	max. 33	69																
23	23	26	58	103																				
24													11		329		11	5	79	85	5	4	76	111
26					22	21	55	90	9	4	54	98												
30	14	8	72	111																				
7/2													2		331		2	0	81	85	0	0	76	111
3					5	7	60	97	2	0	50	98												
7	4	5	76	116																				
9													0		331		0	0	81	85	2	0	78	111
10					1	1	61	98	0	0	56	98												

*R=Collected in September. B=Collected in January. Max.=Maximum.
Larvae collected in September and January showed an emergence of about 50 per cent.

TABLE 2

Bait Pan Records at Glassboro, Codling Moth, 1926

Date	NUMBER OF ADULTS OF CODLING MOTH COLLECTED IN BAIT PANS											Temp.	
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	Total	Min.	Max.
5/29	0	0	0	0	0	0	0	0	0	0	0.0	49	71
30	0	0	0	2	0	0	0	0	1	0	3.0	49	73
31	1	0	0	0	0	0	0	0	0	0	1.0	55	72
6/1	0	0	1	0	0	0	0	0	0	0	1.0	59	71
2	0	0	1	0	0	0	0	0	0	0	0.0	61	83
3	1	0	0	0	1	0	0	0	0	0	2.0	60	81
4	Pans full of Water Replaced June 7											49	73
7	0	0	0	0	0	0	0	0	0	0	0.0	45	60
8	0	0	0	0	0	0	0	0	0	0	0.0	50	70
9	0	0	0	0	0	0	1	0	1	0	2.0	48	76
10	0	0	0	1	0	0	0	0	0	0	1.0	50	80
11	2	0	0	0	0	0	0	0	0	0	2.0	49	81
12	1	0	1	0	0	0	0	0	0	0	2.0	55	79
13	0	0	0	0	0	0	0	0	0	0	0.0	55	80
14	0	2	0	0	1	1	0	0	0	0	4.0	60	84
15	1	0	0	0	1	4	1	0	0	0	7.0	63	91
16	0	0	0	0	0	1	0	0	0	0	1.0	50	83
17	0	1	0	3	0	1	0	0	0	1	6.0	41	61
18	0	0	0	4	0	1	0	0	0	0	5.0	45	61
19	0	1	0	1	0	3	0	0	0	0	5.0	45	70
20	0	0	0	0	0	0	0	0	0	0	0.0	50	74
21	0	2	1	0	0	3	1	0	1	2	10.0	40	75
22	0	2	1	0	2	1	2	0	1	1	10.0	46	73
23	1	1	0	0	1	0	0	0	0	1	4.0	64	87
24	0	0	0	0	0	0	0	0	0	0	0.0	60	74
25	0	0	0	0	0	0	0	0	0	1	1.0	55	79
26	Changed Bait											58	82
27												60	74
28	1	2	7	3	0	0	2	0	0	0	15.0	58	84
29	2	0	0	0	0	1	0	3	0	0	6.0	55	80
30	3	4	1	2	0	2	4	1	1	0	18.0	50	84
7/3	0	0	0	0	0	0	0	0	0	0	0.0		
4	0	0	0	0	0	0	0	0	0	0	0.0		
5	0	0	0	0	0	0	0	0	0	0	0.0		
6	0	0	0	0	0	0	0	0	0	0	0.0		
7	0	0	0	0	0	0	0	0	0	0	0.0		
8	0	0	1	0	0	0	0	0	0	0	1.0		

The results from this test up to approximately June 30 are included in three tables, the first of which relates to codling moth cage emergence, the second to bait pan records and the third to the dates which the thermal constants for the different stages were accumulated (tables 1-3):

According to the thermal constant study the first adults of codling moth were due at Pattenburg on June 8, at New Brunswick on May 23, at Riverton on May 26, at Glassboro on May 18, and at Bridgeton on May 17. First emergence of the hibernating generation of moths in the codling moth boxes appeared at Pattenburg in the week ending June 8, and at New Brunswick, Riverton, Glassboro, and Bridgeton in the week ending May 29. Bait pan records

Table 3

Dates Based on Thermal Constants, Codling Moth, 1926

Hibernating Stages of Codling Moth	Pattenburg		New Bruns.		Riverton		Glassboro		Bridgeton	
	Accum. Temp.*	Date	Accum. Temp.*	Date	Accum. Temp.*	Date	Accum. Temp.*	Date	Accum. Temp.*	Date
Hibernating Generation										
First Adults ...	340	6/8	340	5/23	340	5/26	340	5/18	240	5/17
First Generation										
First Larvae ..	550	6/24	550	6/11	550	6/18	550	6/6	550	6/2
First Adults										

*Accum. Temp.=Accumulated Temperature.

at Riverton by Dr. Peterson showed the first moth on May 18 and his most favorably placed open cages showed one emergence on the same date. On May 14 two fresh pupal skins were found on tree trunks in Glassboro. These data would seem to indicate that the thermal constant figure is not far off, but that hibernating larvae drawn from a central point and placed in boxes of this type show emergence a little early when carried north and a little late when carried south.

According to the thermal constant the first larvae were due to appear in Pattenburg on June 24, at New Brunswick on June 11, at Riverton on June 18, at Glassboro on June 6, and at Bridgeton on June 2. As a matter of fact, larval injury surrounded by reddish tissue was observed at Pattenburg on July 2. This reddening of the tissue is a process that normally takes several days and it is, therefore, reasonable to say that the injury began right at the end of June. As a matter of fact, larval injury of the same stage appeared in the Glassboro district about June 11, indicating that it had begun about June 7 or 8 and possibly as early as the fourth or fifth. Thus, it appears that the thermal constant determination for the appearance of the first larvae is very close to the facts as observed in the orchards and that the apparent differences between the thermal constant rate and the codling moth cages may very well be due to the methods used in securing the material and in the distribution and placing of the cages.

The maximum emergence of the codling moth in the boxes occurred at Pattenburg and at New Brunswick in the week ending June 19, at Riverton in the week ending June 12, and at Glassboro and at Bridgeton in the week ending June 5. Under the scheme used in prevous years spraying would begin at Pattenburg on June 16, at New Brunswick on June 19, at Riverton on June 11, and at Glassboro and Bridgeton on June 4. If advice to spray were issued to the growers at the time the thermal constant indicated that the first larvae were active, the spraying would begin at the time when the codling moth cages indicated it should at Bridgeton and Glassboro, the region in which the codling moth hibernating larvae were collected, but at Riverton it would have started at least a week too late, at New Brunswick a week too early and at Pattenburg a week too late. As a matter of fact, the cold nights at Pattenburg, in all probability, would have made the week's delay ineffective in affecting codling moth side-worm control. The codling moth box at New Brunswick was kept in the screen insectary, which was more or less shaded by the building to which it was attached, and by the trees which over-hung it, and the emergence from the codling moth cage, at New Brunswick, therefore, was probably delayed by about that much. At Riverton the maximum and minimum thermometers were attached to the trunk of a large tree growing in the yard of Mr. H. G. Taylor, and for this reason were subject to much shade and to cool soil. It is probable that the thermal constant indication, because of these conditions, arrived about one week later than it would have, had the thermometers been placed on a post in the open, as is the usual procedure. At this point, it should be said that the thermometers were enclosed in open-bottom, white pine, white painted boxes. These variations indicate distinctly that the greatest care must be exercised in placing the thermometers and codling moth boxes where they will be subject to typical orchard conditions, as are the tree trunks of the apple trees on which the larvae pass the winter.

The upshot of the comparative study of indicators thus far indicates that the thermal-constant method has considerable merit.

Examination of the bait-pan records, which were obtained from ten pans located in an orchard at Glassboro, show distinctly that while they may be taken as an index of the presence or absence of the codling moth in the orchard where they are located, they cannot be depended upon to indicate clearly and unmistakably the period of maximum emergence. On cold and windy nights no codling moths appear in the pans, although they may be present in the orchard. On cold and windy nights very few, if any, eggs seem to be deposited and the bait-pan records may be taken as an indication not only of when the moths are present but when they are sufficiently active to lay eggs, for when they are active they enter the baits.

In summarizing the results of this study thus far, it may be said that the thermal constant used in conjunction with the codling moth cages forms a pretty good indicator of the time when spraying for the side-worms of the first brood should take place. The bait pan is chiefly important where the codling moth infestation has, in previous years, been dense and injury large.

As has been previously set forth, where codling moth injury has been very serious, satisfactory results in spraying for its control come only when the fruit is kept completely coated with a film during the period of entry by side-worms of the first and second brood. Here the bait-pan indicator is extremely valuable, for as soon as the activity of the codling moth under these conditions is sufficient to cause it to enter the bait pan, the time for coating has arrived and the film coating of the fruit must be maintained until the moths no longer appear in the bait pans. In dealing with codling moth control in an area where the infestation on unsprayed fruit does not exceed 50 per cent of the picked fruit, the thermal constant and the codling moth cage become extremely important for, as a rule, one thorough spraying resulting in a coating of the fruit, applied immediately after the time of maximum emergence in the first brood and just previous to maximum emergence in the second brood, effects a satisfactory control of side-worm injury of each brood.

The Codling Moth at Glassboro

A number of the apple growers in the Glassboro district reached the decision that the codling moth was doing them sufficient injury to justify a vigorous concerted effort to control it. Accordingly, a group, whose holdings involves 1,376 acres, effected a simple organization and requested the entomologist to supervise their spraying operations.

In this block of bearing orchards in 1925 the codling moth succeeded in entering an average of about 48 per cent of the fruit harvested at picking time. Of course, much of this entry involved only one pinhole per apple and could not be charged with rendering all the infested fruit unsalable. It is, therefore, probable that the average percentage of the fruit rendered unsalable by the codling moth in this block of bearing orchards did not exceed 25 per cent.

The following plan of procedure was adopted and has been carried out in the season of 1926 insofar as the adequacy of the orchard spraying equipment and management would permit. The results on June 30 may be stated as a condition of the fruit far freer from worms than had existed in most of this acreage for the past several years. As might be expected, some of these orchard properties were almost entirely free from worm injury on fruit on the above date. In fact, no injury whatever could be found in one of these orchards. In others some small injury could be detected, and in others larger amounts of injury. There seemed to be a direct correlation between the faithfulness with which the film coating was maintained during the period of entry by the side-worms of the first brood and the freedom from injury. The final results of this effort can be recorded only when the fruit is ready to pick.

Plan for Treatment of Certain Glassboro Orchards

FOREWORD

These plans were formulated in the course of a meeting of certain orchard owners and operators, held at the Franklin Inn in Glassboro on March 11, 1926. It was agreed by the growers that drastic action against the codling moth had become necessary to the successful growing of apples in their plantations because the codling-moth injury during the season of 1925 ranged from 15 to 80 per cent of the picked fruit and appeared both in the form of culls and low-grade fruit.

It was agreed that the New Jersey Station representatives should specify what spray materials to use, when to use, and how to apply. It was agreed that the growers would follow directions faithfully, equipping themselves with machinery, materials and labor as needed. It was further agreed that needed measures of orchard sanitation, such as prevention of moth emergence from storage and the use of burlap bands, should be promptly carried out by the growers when and in the manner described by the New Jersey Station representatives.

It is, of course, obvious that a spraying program for codling-moth control must also include treatments to protect the fruit from other insects and plant diseases and the following plans, accordingly, will be found to include these additional matters.

DELAYED DORMANT SPRAY

This spray should begin at the earliest indication of the "silver bud" and be completed before the leaves project noticeably from the fruit buds.

It should consist of miscible oil at the manufacturer's recommended strength, or of stabilized oil emulsion used at the rate of 3 gallons to 97 gallons of water. A tree 18 feet to 20 feet tall and 25 feet in diameter should receive about 8 gallons of spray applied in such a way as to coat it from the ground to the tip ends of the smallest twigs.

This treatment is intended to kill the overwintering eggs of the European red mite and San José scale.

PINK-BUD SPRAY

This spray should begin as soon as Stayman and Delicious show color, and be pushed as rapidly to completion as is possible. It must be finished before any of the flower buds closely approach the opening stage.

It should consist of 1 gallon of commercial lime-sulfur solution to 40 gallons of water to which lead arsenate is added at the rate of 1½ pounds to 50 gallons. A tree of the size above mentioned should receive about 8 gallons. It should be applied in such a fashion as to coat all parts of the tree, except the trunk and larger branches.

The purpose of the lime-sulfur is to kill apple scab and of the lead arsenate to kill tent caterpillar and canker worms. If these insects are known to be absent the lead arsenate may be omitted.

BLOSSOM-FALL SPRAY

This spray should begin when the blossoms are practically all off and must be pushed to completion within six or seven days, or the calices will have closed and can not be poisoned.

This spray should consist of 12½ pounds of New Jersey Dry-Mix, 1½ pounds of lead arsenate, and 1 pound of powered sweet skimmed milk or casein sticker to 50 gallons of water. The 1 pound of sticker is additional to the ½ pound already present in the 12½ pounds of Dry-Mix. For the size of tree mentioned above (18 to 20 feet tall and 25 feet in diameter) about 9 gallons of spray will be needed. This spray should be applied from above in such a manner as to hit the upturned calices and to leave a deposit of poison in them.

The sulfur included in this treatment is intended to prevent apple-scab infection. The lead arsenate is intended so to poison the calyx cups that they will remain deadly to all codling moth worms which may attempt to penetrate the blossom-end of the fruit. The arsenate of lead is also intended to start the protection of the fruit from curculio sting or puncture. The powdered sweet skimmed milk or casein sticker is intended to help form a film coat and to increase the adherence of the material to foliage and fruit. This spray starts the building up of the coating which should be maintained during the forepart of the growing season.

SEVEN-DAY-AFTER-BLOSSOM-FALL SPRAY

Beginning where the blossom-fall spray began, start covering the orchard again in 7 days after the falling of the blossoms, and continue until the plantings have been coated.

This spray has precisely the same composition as the blossom-fall spray and needs the same number of gallons per tree. It should be applied in such a way as to film-coat both fruit and foliage.

The purpose of this spray is to afford additional protection from apple scab through the medium of the sulfur used and to give protection from curculio sting or puncture through the lead-arsenate component. In fact, this spray has been especially designed to afford protection from curculio. If that insect were not present, it would certainly have been omitted.

SEVENTEEN-DAY-AFTER-BLOSSOM-FALL SPRAY

Beginning 17 days after the blossom-fall spray again cover the orchard.

This spray consists of 12½ pounds of Dry-Mix, 2 pounds of lead arsenate and 1 pound of powdered sweet skimmed milk or casein sticker to 50 gallons of water. It should be so applied as to film-coat both fruit and foliage and will require about 10 gallons for a tree 18 to 20 feet high and 25 feet in diameter.

The purpose of this spray is to afford additional protection from apple scab through its sulfur content, to complete through its lead arsenate the protection from the curculio, and to begin protection from the first-brood side-worms of the codling moth.

FIRST SIDE-WORM SPRAY

The time when this sppray should be applied will be determined by the development of the codling moth and word will be furnished when it should be given.

This spray has the same composition as the 17-day and the tree requirements are also about the same. When treating early apples, omit all sticker in this treatment. This is a cover spray and both sides of the foliage and all sides of the apple should be film-coated.

The purpose of this spray is to destroy the entering worms of the first brood of codling moth and to continue protection against the apple scab. This completes the spraying for early apples.

POSSIBLE ACCESSORY SPRAYS

From the application of the preceding spray the film coating should be maintained until the first-brood side-worms have ceased to enter. Any sprays given for this purpose should have the same composition as the first-brood side-worm spray, except that the Dry-Mix may be reduced to 8 pounds to 50 gallons.

SECOND-BROOD SIDE-WORM SPRAY

The time of the application of this spray will be determined by the development of the codling moth and notice will be given when it is due.

The composition of this spray is 8 pounds of Dry-Mix, 2 pounds of powdered lead arsenate and 1 pound of additional sticker (powdered sweet skimmed milk or casein) to 50 gallons of water. About 10 gallons will be required for a tree 18 feet to 20 feet high and 25 feet in diameter. This is another cover spray and should be applied in such a fashion as to coat both surfaces of the foliage and all sides of the fruit.

The purpose of this spray is to protect the fruit from entering side-worms of the second brood of codling moth.

POSSIBLE ACCESSORY SPRAYS

It is possible that treatments may be required after the application of the preceding sprays. If so, they should have the same composition, except that all stickers should be omitted.

Oriental Peach Moth

The work against the Oriental Peach Moth has been carried on by Mr. Louis A. Stearns and certain temporary assistants. Mr. Stearns' report of his work follows:

A Report on the Investigation of the Oriental Peach Moth (*Laspeyresia molesta* Busck) for 1925

LOUIS A. STEARNS

Biological Studies

Aside from enlarging slightly upon its scope, no departures were made in the conduct of this phase of the investigation during 1925. For comparative reasons the problem was approached, as in the preceding year, from four angles: first, a detailed study of the seasonal life history of the insect under insectary conditions; second, young peach trees in the orchard adjoining the insectary were caged and the life history and habits were thus further recorded as a correction upon the slightly subnormal insectary conditions; third, observations on larval development and the conditions of infestation were made in six different localities in the state; fourth, a study of the attractiveness of baits was continued and elaborated upon by observations on dispersion. The results of these several lines of endeavor are summarized herewith.

Insectary Life History

The data secured in 1925 in regard to the length of time required for the incubation of the egg, for the feeding to maturity of the larva and for the construction of its cocoon, for the duration of the pupal stage and finally, for the development of each single generation in these several stages combined are comparable with and confirm the data accumulated in 1924. The information in regard to the seasonal life history conducted in the insectary has been summarized in table 1.

The detailed records for both years are being prepared for publication in bulletin form. In 1925, as in 1924, there were three complete broods and a partial fourth brood of this insect at New Brunswick. The few and slight irregularities in the life histories for the two years can be readily explained as anticipated seasonal variations due to temperature differences.

In figure 1 the records of adult emergence at New Brunswick during 1925 are plotted by a full line with the similar records for 1924 superimposed by a dash line. The emergence periods for the spring and first broods of the successive years are coincident. Differences at the very beginnings and the extreme ends of these curves are apparent, however. A scattering emergence occurred in 1925 over a period of 12 days prior to the first emergence record for 1924. The slightly earlier autumn of 1925 resulted in a displacement of the second and third-brood emergence forward so that the late August ripening varieties received a somewhat more severe third-brood larval infestation than during the season preceding. In 1924 the peak of third-brood emergence was not reached until late September and emergence did not end until the nineteenth of October.

Life History on Caged Peach Trees

For the season of 1925 eight large 3-year-old trees were enclosed in an 8 by 8 by 8-foot cage. The covering of these cages was a fine 40 by 44 mesh cotton gauze. For each brood two cages were used. The first adults to appear were placed in the first cage of each brood, while the last adults to emerge were placed in the second cage of each brood. Daily examinations of all cages in operation were made and all details of the life cycle were checked insofar as

TABLE 1

Summary of the Insectary Seasonal Life History of the Oriental Peach Moth, New Brunswick, N. J., 1925

GENERATIONS	EGG STAGE				LARVAL STAGE								PUPAL STAGE				COCOON PERIOD Prepupal and Pupal)				LIFE CYCLE EGG TO ADULT			
		Length of Incubation Period				Length of Feeding Period				Length of Cocooning (Prepupal) Period				Length of Pupal Stage				Length of Cocoon Period				Length of Life Cycle		
	Total	Minimum	Maximum	Average	Total	Minimum	Maximum	Average	Total	Minimum	Maximum	Average	Total	Minimum	Maximum	Average	Total	Minimum	Maximum	Average	Total	Minimum	Maximum	Average
		days	*days*	*days*		*days*	*days*	*days*		*days*	*days*	*days*		*days*	*days*	*days*		*days*	*days*	*days*		*days*	*days*	*days*
First	*10586	4	18	4.7																				
Transforming, 100.0 per cent	‡ 1165	4	18	4.8	1094	3	26	14.3	1035	1	12	3.6	784	5	18	9.2	781	7	29	12.8	All 838	23	55	31.9
																					Male 403	23	47	31.5
																					Female 435	23	55	32.3
Second	* 9289	4	6	4.6																				
Transforming, 97.2 per cent	‡ 2298	4	6	4.5	1903	8	25	13.9	1130	1	11	2.9	1092	5	18	10.6	1585	7	26	13.2	All 1936	24	47	31.7
																					Male 977	24	47	31.6
																					Female 959	24	46	31.8
Wintering, 2.8 per cent	‡ 66	4	6	4.7	66	8	22	14.2																
Third	*12502	4	6	4.7																				
Transforming, 46.6 per cent.	‡ 1320	4	6	4.8	1158	7	23	12.1	120	2	5	3.0	205	7	25	10.9	1060	9	28	14.3	All 1203	22	48	31.05
																					Male 548	25	42	30.8
																					Female 655	22	48	31.2
Wintering, 53.4 per cent	‡ 1515	4	6	4.7	1148	8	26	15.9																
Fourth	*10281	5	10†	5.9																				
Wintering, 100.0 per cent	‡ 392	5	6	5.0	329	8	27†	16.3																

*All material.

‡Material selected for further study of development.

†Study concluded October 5, some eggs deposited just prior to this date exceeded 10 days for incubation and 27 days for feeding.

was possible. Table 4 summarizes some of the results obtained from this study by presenting the extremes for the duration of the successive broods of 1925.

MISCELLANEOUS FIELD OBSERVATIONS ON LIFE HISTORY

During the late winter and spring of 1925, records were secured on the progression in transformation of over-wintered larvae by weekly examinations, from February 13 until May 8, of material in an old quince planting near Burlington. These data, which have been summarized and compared with similar data from New Brunswick in table 3 show that on April 3 with approximately 70 per cent of the larvae pupated at Burlington, less than 1 per cent had transformed at New Brunswick; again, that on April 24 when the first spring-brood adult emerged at New Brunswick fully one-third of the moths of this brood were emerged at Burlington. The impetus given the seasonal life history of the moth at this time in the Burlington-Riverton district resulted in the development of an additional partial brood at the close of the summer, a factor determined by the larval collection records for Riverton (p. 188). Other larval collection records for Bridgeton and Hammonton point to the probability of an additional partial brood at these localities as well.

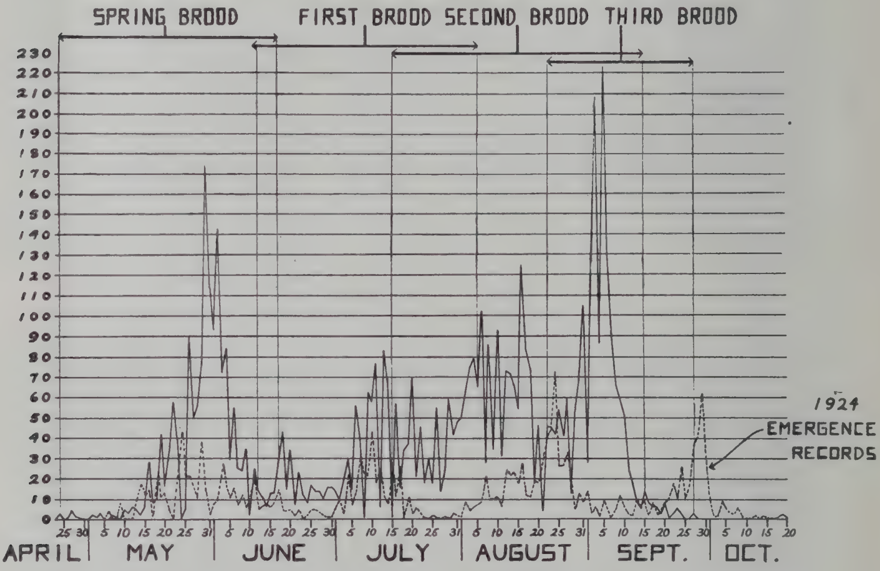


FIG. 1. COMPARISON OF ORIENTAL PEACH MOTH ADULT EMERGENCE CURVES FOR 1924 AND 1925, NEW BRUNSWICK, N. J.

LARVAL DEVELOPMENT IN THE ORCHARD, CONDITIONS OF INFESTATION AND PARASITISM

Observations on larval development and the conditions of infestation by the peach moth were made in six different localities in the state—at the College Fruit Farm, New Brunswick, at H. G. Taylor's orchard, Riverton, at the Del-Bay Farms, Inc., Bridgeton, at Layton Parkhurst's orchard, Hammonton, at John Hendrickson's orchard, Middletown, and at John Hankinson's orchard, Glen Moore. These orchards were visited weekly on 18 successive weeks from approximately May 15 until September 15. Larvae were collected from injured twigs for exactly 1 hour. The larvae of each collection were sized according to their length in millimeters (2 mm.—just hatched to 10 mm.—

TABLE 2

TABLE 2

Summary of the Seasonal Life History of the Oriental Peach Moth on Caged 3-Year-Old Peach Trees for 1925, Showing Extremes for the Successive Broods, New Brunswick, N. J.

Date 1925		First Brood				Second Brood				Third Brood				Fourth Brood			
		Early-Cage 1		Late-Cage 2		Early-Cage 3		Late-Cage 4		Early-Cage 5		Late-Cage 6		Early-Cage 7		Late-Cage 8	
		Spring-Brood Moths Inserted	First-Brood Moths Emerged	Spring-Brood Moths Inserted	First-Brood Moths Emerged	First-Brood Moths Inserted	Second-Brood Moths Emerged	First-Brood Moths Inserted	Second-Brood Moths Emerged	Second-Brood Moths Inserted	Third-Brood Moths Emerged	Second-Brood Moths Inserted	Third-Brood Moths Emerged	Third-Brood Moths Inserted	Fourth-Brood Moths Emerged	Third-Brood Moths Inserted	Fourth-Brood Moths Emerged
April	24	1 2 3															
"	25	0 0 0															
"	26	0 2 2															
"	27	4 1 5															
"	28	1 0 1															
"	29	0 0 0															
"	30	0 0 0															
May	1	0 0 0															
"	2	1 1 2															
"	3	0 1 1															
"	4	0 3 3															
"	5	0 0 0															
"	6	0 0 0															
"	7	1 1 2															
"	8	1 0 1															
"	9																
"	10	9 11 20															
"	11																
"	12																
"	13																
"	14																
"	15																
"	16																
"	17																
"	18																
"	19																
"	20																
"	21																
"	22																
"	23																
"	24																
"	25																
"	26																
"	27																
"	28																
"	29																
"	30																
"	31																
June	1																
"	2																
"	3																
"	4																
"	5																
"	6																
"	7																
"	8																
"	9																
"	10																
"	11																
"	12					2 0 2											
"	13			3 6 9		1 0 1											
"	14			4 1 5		0 2 2											
"	15		1 1 2	0 6 6		3 3 6											
"	16		7 1 8	0 5 5		7 4 11											
"	17		8 10 18	2 7 9													
"	18		17 15 32	6 2 8		13 9 22											
"	19		5 4 9	1 5 6													
"	20		8 9 17	1 0 1													
"	21		4 3 7	2 2 4													
"	22		6 3 9														
"	23		5 1 6	19 34 53													
"	24		3 1 4														
"	25		1 4 5														
"	26		3 3 6														
"	27		2 0 2														
"	28		0 0 0														
"	29		1 0 1														
"	30		0 1 1														
July	1		0 0 0														
"	2		0 1 1														
"	3																
"	4		71 57 128														
"	5																
"	6																
"	7																
"	8																
"	9																
"	10																
"	11																
"	12																
"	13																
"	14																
"	15									0 1 1							
"	16				1 0 1		4 3 7			4 4 8							
"	17				0 1 1		5 1 6			5 1 6							
"	18				0 0 0		2 5 7			3 6 9							
"	19				0 0 0		8 4 12										
"	20				0 4 4		0 0 0			12 12 24							
"	21				2 2 4		1 0 1										
"	22				3 3 6		0 0 0										
"	23				6 3 9		2 1 3										
"	24				3 1 4		2 0 2										
"	25				2 1 3		1 0 1										
"	26				5 4 9			3 2 5									
"	27				1 2 3		25 14 39	3 1 4									
"	28				0 0 0			4 4 8									
"	29				4 2 6			0 1 1									
"	30				0 0 0			3 1 4									
"	31				2 1 3			3 2 5									
Aug.	1				3 2 5			1 3 4									
"	2				1 3 4			0 2 2									
"	3				0 0 0												
"	4				0 0 0			17 16 33									
"	5				0 2 2												
"	6																
"	7				33 31 64												
"	8																
"	9																
"	10																
"	11																
"	12																
"	13																
"	14																
"	15																
"	16																
"	17																
"	18																
"	19																
"	20																
"	21																
"	22																
"	23													1 1 2			
"	24										9 6 15			4 5 9			
"	25										2 4 6			3 0 3			
"	26										0 0 0			9 6 15			
"	27										0 1 1						
"	28										0 0 0			18 11 29			
"	29										0 1 1						
"	30										0 1 1						
"	31										0 0 0						
Sept.	1								1 0 1		0 0 0						
"	2								0 1 1		0 1 1						
"	3								1 0 1								
"	4								1 3 4		11 14 25						
"	5								4 2 6								
"	6								2 2 4								
"	7								2 4 6			9 4 13					
"	8								1 0 1			6 6 12					
"	9								3 0 3			1 2 3					
"	10								1 2 3			4 1 5					
"	11								1 0 1			2 3 5					
"	12								1 1 2			1 0 1					
"	13								0 1 1			1 1 2					
"	14								0 1 1			0 1 1					
"	15								0 1 1			0 1 1					
"	16											0 1 1					
"	17								18 18 36							0 5 5	
"	18											24 20 44				2 4 6	
"	19															1 1 2	
"	20															3 5 8	
"	21															1 0 1	
"	22															2 1 3	
"	23															0 0 0	
"	24															2 1 3	
"	25															0 0 0	
"	26															0 0 0	
"	27															0 3 3	
													* * *		* * *	11 20 31	* * *

*Records completed by emergence of spring brood moths in 1926.

mature), the total recorded, and the material taken to the insectary at New Brunswick in order to secure emergence records. The data thus obtained were indicative of the relative severity of the several infestations, the progress in development of the successive broods, the transfer from twig to fruit feeding, the extent of parasitism and the decline in infestation due to this factor. This information for the several localities in which observations were made is shown graphically in figures 2 to 7.

Table 3

A Comparison of the Progression in Transformation of Spring-Brood Pupae and in Emergence of Spring-Brood Moths, Burlington and New Brunswick, N. J., 1925

Observation Dates, 1925	Pupated		Emerged	
	Burlington	New Brunswick	Burlington	New Brunswick
	per cent	*per cent*	*per cent*	*per cent*
February 13	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
24	0.6	0.0	0.0	0.0
March 9	19.1	0.0	0.0	0.0
16	37.3	0.0	0.0	0.0
23	42.3	0.0	0.0	0.0
April 3	69.8	0.8	0.0	0.0
9	79.4	1.5	4.6	0.0
16	87.4	9.9	20.5	0.0
23	95.7	24.4	30.6	0.0
May 1	98.3	52.7	60.3	0.7
8	100.0	71.8	86.7	1.3
15		90.1		3.1
22		97.7		16.5
28		100.0		32.8
June 4				83.9
9				95.3

Note: Burlington records based upon 2,552 individuals. New Brunswick records based upon 1,469 individuals.

The infestation during the spring of 1925 apparently centered in the Hammonton district with Bridgeton rating an 81 per cent infestation, Riverton 51 per cent, New Brunswick 38 per cent, Glen Moore 30.5 per cent and Middletown 20.5 per cent. The earlier outbreak of a larval parasite (*Macrocentrus*) at Hammonton, accompanied by a continuance of conditions favoring its activities, later reduced this locality to second place with the center of infestation transferred to Bridgeton. Riverton, New Brunswick, Glen Moore and Middletown, retained, however, their positions as third, fourth, fifth and sixth rate infestations throughout the entire season.

The season of 1925, as a whole, was characterized by an unusually extensive parasitic outbreak. Considering each of the collection localities individually, an average of 68 per cent of all larvae collected during the season at Hammonton were parasitized, at Bridgeton 48 per cent, at Riverton 44 per cent, at New Brunswick 26 per cent, at Glen Moore 16 per cent, and at Middletown 15 per cent.

One species, a Hymenopterous larval parasite, *Macrocentrus* sp? (probably *ancylivora* Rohwer, also a parasite of the strawberry leaf-roller (*Ancylis comptana* Frohl.) previously reared in Virginia and Maryland and recorded for the first time in New Jersey in 1924, figured largely in this reduction in infestation. Especially was this true at Riverton, Bridgeton and Hammonton where this species comprised 90, 98 and 96 per cent, respectively, of all parasites reared. Table 4 is included as a record of the number and relative importance of the several species of larval parasites reared from the Oriental Peach Moth in this state in 1925.

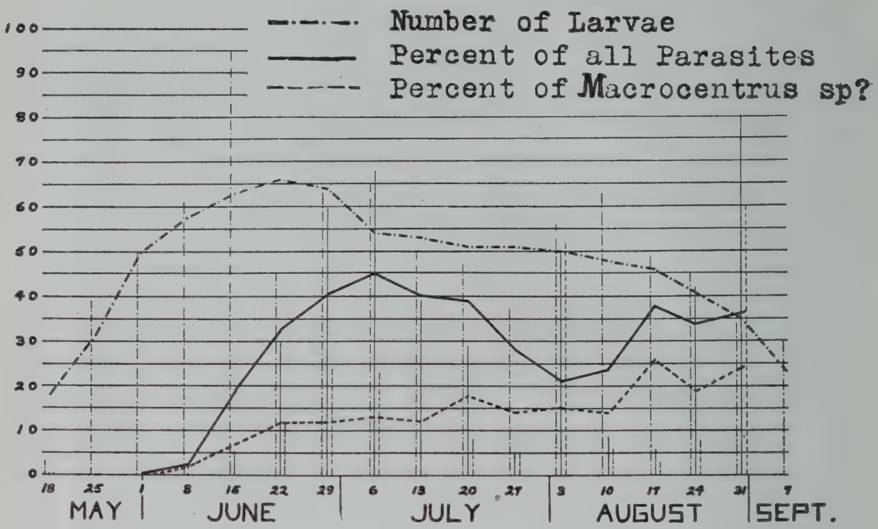


FIG. 2. RECORDS OF LARVAL COLLECTIONS AND THE EXTENT OF PARASITISM, NEW BRUNSWICK, N. J., 1925

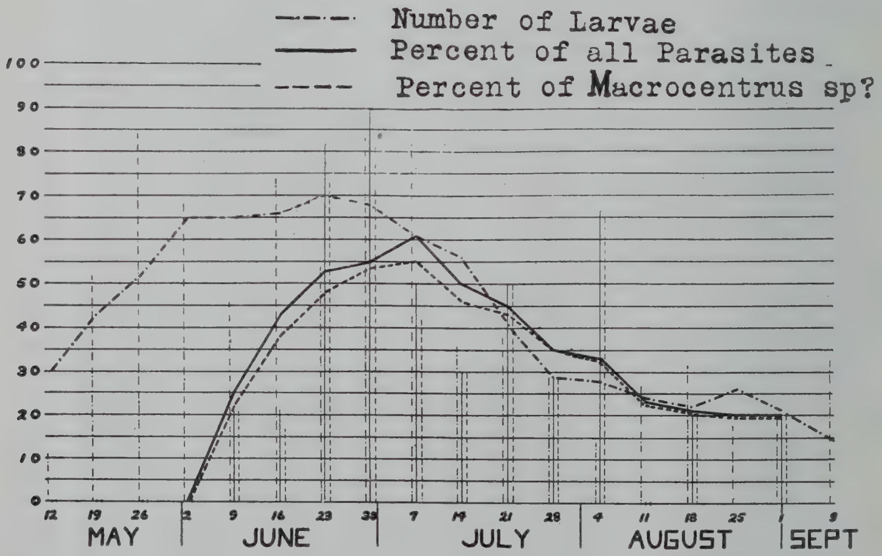


FIG. 3. RECORDS OF LARVAL COLLECTIONS AND THE EXTENT OF PARASITISM, RIVERTON, N. J., 1925

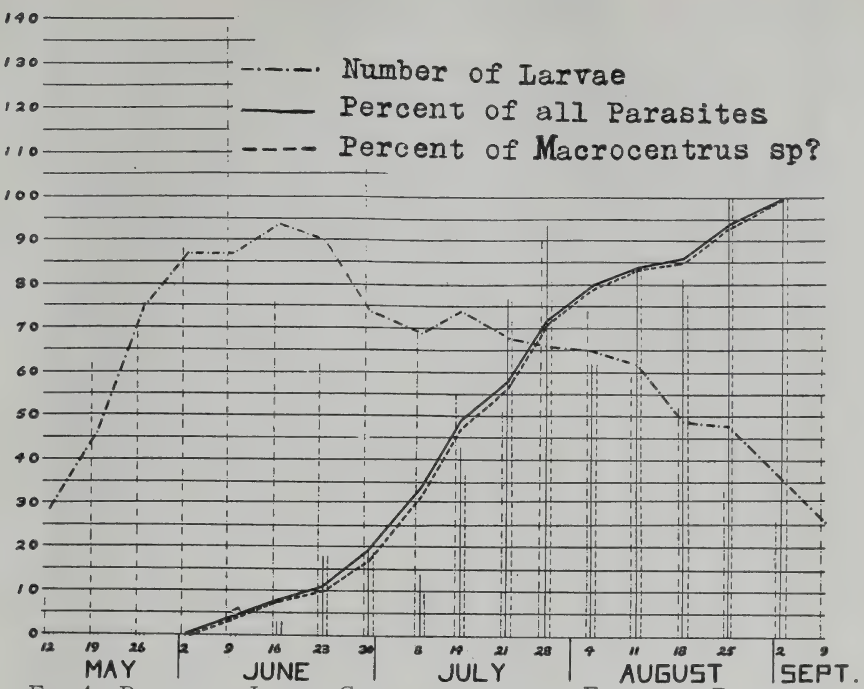


Fig. 4. Records of Larval Collections and the Extent of Parasitism, Bridgeton, N. J., 1925

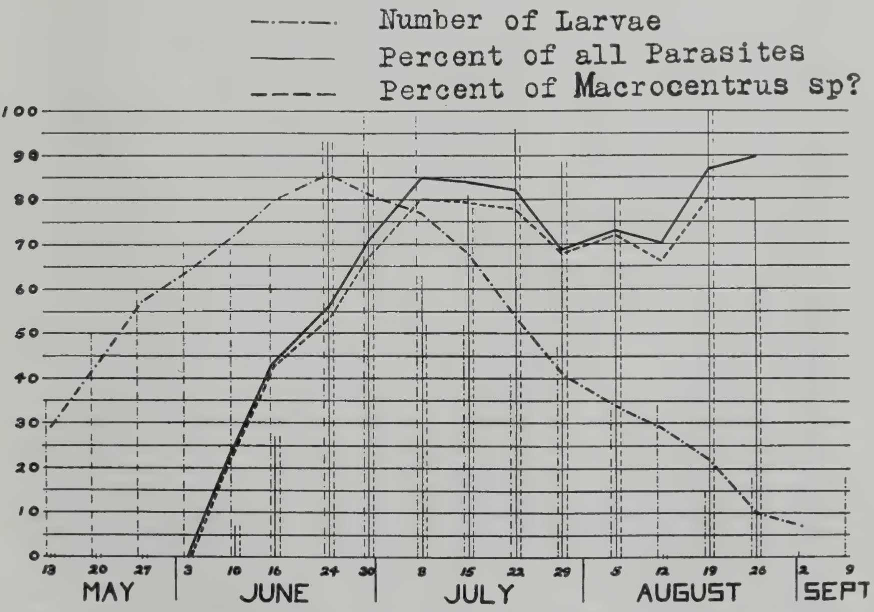


Fig. 5. Records of Larval Collections and the Extent of Parasitism, Hammonton, N. J., 1925

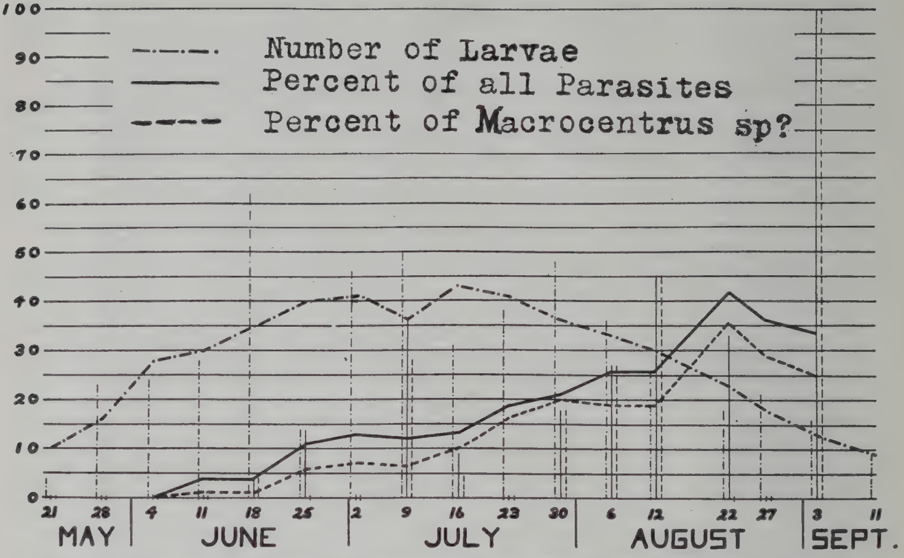


FIG 6. RECORDS OF LARVAL COLLECTIONS AND THE EXTENT OF PARASITISM, MIDDLETOWN, N. J., 1925

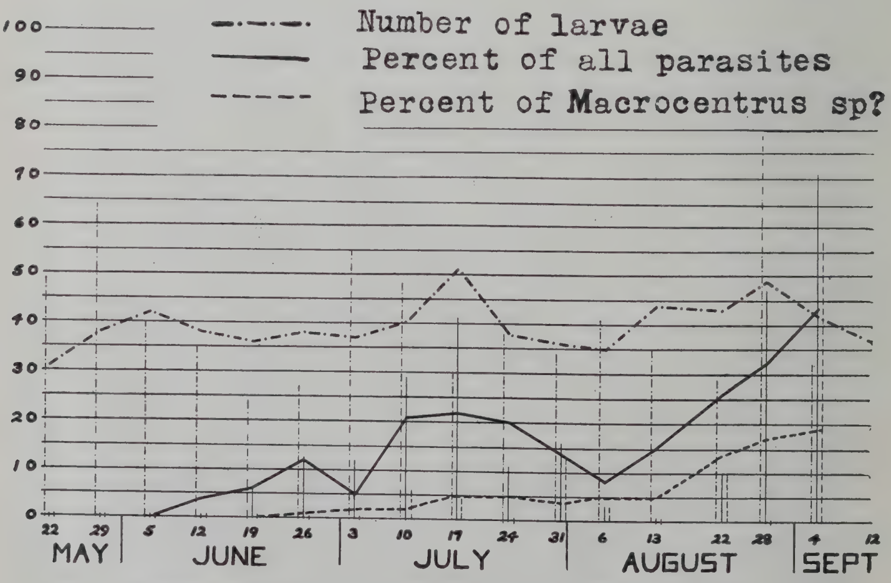


FIG. 7. RECORDS OF LARVAL COLLECTIONS AND THE EXTENT OF PARASITISM, GLEN MOORE, N. J., 1925

TABLE 4

List of Oriental Peach Moth Larval Parasites Reared in New Jersey, 1925*

Primary Parasites	*Number Reared*
1—*Macrocentrus ancylivora* Rohwer	569
2—*Glypta rufiscutellaris* Cress	83
3—*Calliephialtes* sp? (apparently undescribed)	25
4—*Pristomerus ocellatus* Cush	20
5 *Cremastus minor* Cush	10
6—*Cremastus forbesii* Weed	10
7—*Phanertoma tibialis* Hald	8
8—*Ascogaster carpocapsae* (Vier.)	8
9—*Calliephialtes grapholithae* (Cress.)	4
10—*Eubadizon* sp?	4
11—*Centeterus ineptifrons* Gahan	1
12—*Epiurus indagator* (Cress.)	1
13—*Itoplectis conquisitor* (Say)	1
14—*Sagaritis consimilis* (Ashm.)	1
15—*Sagaritis patsuiketorum* Vier	1
16—*Hemiteles* sp?	1
17—*Phygadeum* sp?	1
18—*Microcryptus* sp?	1
19—*Meterus hyphantriae* Riley	1
20—*Diptera* sp?	1
21—*Diptera* sp?	1
Secondary Parasites	
1—*Dibrachys boucheanus* Ratz.	

*Acknowledgment is made here of the determination of these parasites by R. A. Cushman, A. B. Gahan and S. A. Rohwer, U. S. National Museum, Washington, D. C.

ATTRACTIVE BAITS

A study of the response of the adult moths to baits entered upon in 1924 was continued. Although additional baits (particularly apple and vinegar baits) were experimented with, none proved as attractive as the molasses-yeast bait, the efficiency of which had been suggested in the previous season's work, and which had been reported upon by Dr. Alvah Peterson.[1]

This molasses bait, made up in the proportions of 1 part of molasses to 3 parts of water with a single yeast cake added to each 10 gallons of solution, was placed in small stew kettles of a 6-inch diameter and suspended in trees at approximately 5 feet from the ground. Thirteen of these kettles in continuous operation, over a period of 153 days from May 1 to September 30, inclusive, resulted in a total catch of 2,269 moths, 1,218 of which were males and 1,051, females. This total represents 1.1 moths per can per day for the period of operation. The results for this year would seem to indicate that while a bait can or "trap," of the character described, might serve as an excellent adjunct to a life-history study for the determination of emergence in orchard as compared with insectary conditions, its practical value is debatable. In its present status, as a possible control measure for this particular pest it will probably fall into the same category as "banding," a supplementary measure for codling-moth control.

---

[1] Peterson, A., 1925. A Bait which Attracts the Oriental Peach Moth (*Laspeyresia molesta* Busck.). *Jour. Econ. Ent.* 18: 181-190.

Control Studies

The report covering the control phase of this problem for 1924 emphasized two measures as of possible practical value, namely, thorough spring cultivation, and, where the conditions of infestation and prospective yield seem to justify the expense, the addition of 40 per cent nicotine at the 1 to 800 dilution in the summer sprays commencing with the shuck-split application. The results of the further study given these two measures in 1925 will be considered here.

CULTIVATION

The recommendation for the current year in respect to cultivation called for plowing to the depth of six inches, getting as close to the tree as possible without damage to the roots or trunk, this plowing to be followed by a very thorough disking to the depth of at least 4 inches. It was further advised that these operations be completed during the month of April at which time the majority of overwintered larvae have reached the pupal stage. In studying the data secured in 1924 in respect to cultivation as compared with no cultivation, the conclusion was reached that the heavy turnover resulting from the use of the plow was responsible for the burial and consequent destruction of the overwintered larvae, and that the cutting action of the disk alone would not be sufficient to accomplish the desired end.

The evident disinclination on the part of many, who do not plow, to follow the recommendation, pointed to the need of determining as soon as possible the relative merits of plowing alone as compared with disking alone, and further as compared with plowing and disking combined.

Accordingly arrangements were made to secure such information by experiments, one of which was located in an orchard of Byron Roberts, at Five Points, near Palmyra, and the second in the Del-Bay Farms at Bridgeton.

In the Roberts orchard the cultivation treatments were given adjoining 5-acre plots running crosswise through the three varieties, Greensboro, Carmen and Belle of Georgia. The cover crop was rye. Cultivation was commenced on March 31 and concluded on April 2. Further cultivation was withheld for three weeks. The 20-acre block of Belles with a clover cover crop was divided into three equal plots in the Bridgeton experiment.

Irrespective of treatments, the actual fruit loss from the Oriental Peach Moth in the Roberts orchard, as determined by splitting the fruit, averaged but 1.8 per cent for the three varieties mentioned. At the Del-Bay Farms orchard, the Belle infestation averaged 12.6 per cent. The results of these two experiments, as given in tables 5 and 6, show that in neither orchard was there any appreciable difference in the effectiveness of the three treatments. In view of this fact, it seems reasonable to conclude that a thorough disking in the spring should prove as efficient as a combination of plowing and disking for the burial and consequent destruction of the overwintered larvae.

SPRAYING EXPERIMENTS

Although the results of the experimental spraying operations reported for 1924 had confirmed the results of similar work conducted previously in Virginia, it seemed desirable to test further the efficiency of 40 per cent nicotine as an ovicide and partial larvicide for this insect under New Jersey conditions.

One experiment was located at Moorestown in Arthur H. Collins & Sons' orchard and the second for comparative reasons at Bridgeton in the Del-Bay Farms. The writer's participation in the work consisted solely in the selection of the experimental blocks, in recommendations as to spraying dates and in the recording of results at picking time.

At Moorestown a 15-acre planting of Elberta with a cover crop of vetch was divided into two equal plots. One plot, as recommended, was plowed and disked, later receiving 40 per cent nicotine in 6 summer sprays commencing with the shuck-split application; the second plot was disked only and received the 6 summer sprays with no addition of nicotine. Inasmuch as the cultivation tests rule out any advantage due to varying the type of cultivation we must assume that the difference in results is attributable to the addition of nicotine. The results of the experiment in the Collins orchard are given in table 7.

TABLE 5

Results of Experiment to Determine the Effectiveness of Different Cultivation Practices in the Control of the Oriental Peach Moth, Byron Roberts' Orchard, at Five Points, Near Palmyra, N. J., 1925

Plot	Type of Cultivation	Variety	Date of Examination, 1925	†Total Fruit on Tree and Ground	*Infestation			
					Variety		Plot Average	
					No.	per cent	No.	per cent
1	Disked only	Greensboro	7-15	142	7	4.93		
		Carman	8-6	718	11	1.53		
		Belle of Georgia	8-14	591	22	3.72		
				1451			40	2.76
2	Plowed only	Greensboro	7-15	312	5	1.60		
		Carman	8-6	634	6	0.95		
		Belle of Georgia	8-14	560	9	1.61		
				1506			20	1.33
3	Plowed and disked	Greensboro	7-15	122	3	2.46		
		Carman	8-6	934	14	1.49		
		Belle of Georgia	8-14	893	12	1.34		
				1949			29	1.49

*Determined by splitting fruit.

†Data taken from one tree for each variety in each plot.

TABLE 6

Results of Experiment to Determine the Effectiveness of Different Cultivation Practices in the Control of the Oriental Peach Moth, Belle of Georgia Variety, Del-Bay Farms, Inc., Bridgeton, N. J., 1925

Plot	Type of Cultivation	Date of Examination 1925	†Total Fruit on Tree and Ground	Visible Infestation		*Non-visible Infestation		Total Infestation	
				number	*per cent*	*number*	*per cent*	*number*	*per cent*
1	Disked only	8-12 & 13	1891	213	11.26	41	*2.1552	254	13.43
2	Plowed only	8-12 & 13	1677	190	11.33	36	*2.1552	226	13.48
3	Plowed and disked	8-12 & 13	2011	180	8.95	43	*2.1552	223	11.09

*Determined by splitting fruit, one basket from each of six selected trees, and by applying the percentage of non-visible infestation (2.1552) thus figured to the entire crop of these trees.

†Data taken from two trees in each plot.

At Bridgeton, as in 1924, the test plots of five acres each extended crosswise through the four varieties, Slappey, Elberta, Fox Seedling and Krummel's October. They were arranged in series as follows: Plot 1, nicotine included wherever scheduled; Plot 2, nicotine omitted wherever scheduled; Plots 3, 4, 5, 6, 7 and 8, nicotine omissions in the shuck-split, 2, 4, 7, 9 and 11 weeks' applications respectively.

TABLE 7

Effectiveness of Different Cultivation and Spraying Practices for the Control of the Oriental Peach Moth, Elberta Variety, Arthur J. Collins & Sons' Orchard, Moorestown, N. J., 1925

Plot	Type of Cultivation and Spraying	Date of Examination 1925	†Total Fruit on Tree and Ground	Visible Infestation		*Non-visible Infestation		Total Infestation	
				number	*per cent*	*number*	*per cent*	*number*	*per cent*
1	CULTIVATION Disked only SPRAYING Six sprays *without* 40 per cent Nicotine, 1 to 800	8–24	573	54	9.42	10	*1.74	64	11.17
2	CULTIVATION Plowed and disked SPRAYING Six sprays *with* 40 per cent Nicotine, 1 to 800	8–24	934	38	4.07	16	*1.74	54	5.78

*Determined by splitting fruit, one basket from each of six selected trees, and by applying the percentage of non-visible injury (1.74) thus figured to the entire crop of these trees.

†Data taken from three trees in each plot.

The first two plots are comparable with the Moorestown experiment. The remaining six plots were provided, to determine by elimination, if possible, the effectiveness of nicotine in each of the several applications. The entire block of approximately 40 acres was in clover and received the same cultivation, namely, a thorough plowing and disking in the spring. Slappey received five summer sprays commencing with the shuck-split application and the other varieties six. All varieties irrespective of previous treatments received an 80-20 sulfur-lime dust ten days prior to picking.

In recording data, the percentages of fruit injury in 1925 were determined as in 1924 by splitting the entire crop from representative trees in each variety in each of the test plots.

The data obtained concerning the possible elimination of any one of the six recommended nicotine treatments are confined to Elberta alone and are unfortunately, of too limited character to provide the basis for any definite statement at this time.

The results in regard to the omission versus the addition of 40 per cent nicotine 1 to 800 are given in table 8. In the case of the Slappey variety, the percentages of wormy fruit for the two plots in which nicotine was included (plot 1) or omitted (plot 2) wherever scheduled differ by less than 0.5 per cent from the figures of last year. For this variety the increase of clean fruit due to the addition of the nicotine amounted to 12.58 per cent.

The results for the two seasons vary, however, for the Elberta and Krummel varieties. The difference may be due to one or both of two factors—first, parasitism which our larval collection records for this locality show by mid-August assumed proportions sufficient to counteract the effect of the treatments applied; and second, the displacement forward of the later portion of the seasonal life history occasioned by the earlier (compared with 1924) autumn (p. 184). Whatever the casual agent, the increase in clean fruit suffered a reduction from 12.58 to 7.70 and 5.69 per cent respectively, for these later-ripening varieties. This reduction occurred also at Moorestown where brood and parasitic conditions were apparently similar.

The average increase in clean fruit for the three varieties under consideration due to the combination fungicidal-arsenical-nicotine treatment amounted to 8.65 per cent in 1925 as compared with an average of 13 per cent in 1924. This variance approximates almost exactly the high (14 per cent) and the low (8 per cent) limits of the increase range determined over a period of six years' experimental work in Virginia. These results appear to justify the continuance of the recommendation made in 1924 for the addition of 40 per cent nicotine at the 1 to 800 dilution in the summer sprays commencing with the shuck-fall application, when the conditions of infestation and prospective yield would seem to justify the expense.

TABLE 8

Effectiveness of 40 *Per Cent Nicotine for the Control of the Oriental Peach Moth, Del-Bay Farms, Bridgeton, N. J.,* 1925

Plot	Character of Treatment	Variety	Dates of Examination 1925	Total Fruit Including Drops	*Infestation		Reduction
					Variety	Plot Average	
					per ct.	*per ct.*	*per ct.*
1	Five Sprays	Slappey	8-7 & 8	3143	8.59		12.58
	Six Sprays	Elberta	8-19 & 20	1930	11.97		7.70
		Krummel	9-16 & 17	3140	27.58		5.69
	With 40 per nicotine, 1 to 800					16.05	8.65
2	Five Sprays	Slappey	8-7 & 8	2602	21.17		
	Six Sprays	Elberta	8-19 & 20	1793	19.67		
		Krummel	9-16 & 17	4280	33.27		
	Without 40 per nicotine, 1 to 800					24.70	

*Determined by splitting all fruit from six selected trees, Slappey and Elberta varieties, and eight selected trees, Krummell variety.

A Field Study of Oils for Killing European Red Mite Eggs

During the winter of 1925-26 a survey of the orcharding of this state showed a general and reasonably heavy infestation of European red mite eggs. In view of this finding and of the seemingly well established fact that oil sprays were the only means of effecting a satisfactory control, it was decided to run a series of field tests with the principal miscible oils and oil emulsions for the purpose of determining whether the oil emulsions costing, at recommended dilutions, less than one-third the price of miscible oils, at recommended dilutions, would destroy the mite eggs equally well. These materials were tried against the European red mite on both peach and apple. Blocks were selected and treatments were made at the delayed dormant period on apple and, just before the leaf buds opened to allow projection of the leaves, on peach. The results of this test are set forth in table 1.

TABLE 1

Effectiveness of Oil Against the Eggs of European Red Mite

Block No.	Treatment	Total Eggs	Eggs Unhatched	
	Apples at Paul Burk's Farm—Bridgeboro, 1926			
			number	*per cent.*
1	Target Brand Scale Oil (1 to 20)	3172	2650	83.5
2	Keystone Emulsion (1 to 33)	3562	2527	70.9
3	Key Brand Emulsion (1 to 33)	2127	1472	69.2
4	Mechling's Emulsion (1 to 33)	1783	1347	75.5
5	Mechling's Scale Oil (1 to 20)	1651	1256	76.0
6	Sunoco Spray Oil (1 to 20)	1507	1165	77.3
	Peaches at Hulsart Farm—Manasquan, 1926			
1	Keystone Emulsion (1 to 33)	1717	1365	79.5
2	Key Brand Emulsion (1 to 33)	2175	1560	71.8
3	Target Brand Scale Oil (1 to 20)	1875	1335	71.2
4	Mechling's Scale Oil (1 to 20)	1916	1054	55.1
5	Mechling's Emulsion (1 to 33)	2027	1380	68.1
6	Sunoco Spray Oil (1 to 20)	1665	1120	67.3
Average of Miscible Oils on Apple		6330	5071	80.1
Average of Oil Emulsion on Apple		7472	5346	71.4
Average of Miscible Oils on Peach		5456	3409	62.3
Average of Oil Emulsions on Peach		5919	4305	72.7

In general, the variations are sufficiently limited to indicate that the oil emulsions and miscible oils have approximately the same value, although the oil emulsions run an actual oil content of about 2 per cent, while the miscible oils run an actual oil content of about 4 per cent. Thus it appears that the oil emulsions, percentage of oil for percentage of oil, are about twice as toxic as are the miscible oils. The underlying reason for this difference is explained in another section of this report (p. 207). Burning of buds following the delayed dormant spray was absent in the case of both peach and apple. The resultant control, not only in these orchards, but practically all over the state, has been excellent, because, the entomologist believes, of weather conditions unfavorable to the propagation of the mite. Had the season been warm and dry the control would probably not have been nearly so satisfactory. He feels that with the method of applying spray materials generally utilized in this state an increase in the oil content of the diluted oil sprays is advisable.

Some Tests of Para-dichlorobenzene Dissolved in Soluble Pine Tar Creosote in the Control of Boring Insects in Living Plants

C. C. HAMILTON

Introduction

For a considerable time there has been need of a material which can be safely used in treating ornamental shade trees and shrubbery plants for insects boring in the bark, cambium layer and woody part of the plant. Such a material must have the power of penetrating the burrows of the boring insect, it must be toxic to the insect and, in addition, it must be non-injurious to the growing plants. Tar oils of various kinds, principally carbolineum, have been used and recommended for some years in Europe for treating growing plants to repel boring insect attacks and in some cases, to kill them after they have entered the plants. The use of this material in the United States has not received much attention, probably because of the difficulty of application and the fact that the control produced has not been entirely satisfactory.

Among the first work done in the United States, in the use of tar oils as remedies for boring insects in living plants, is that of Matheson[1], in which he tested a number of materials against the larvae of the mottled poplar and willow borer (*Cryptorhynchus lapathi* Linnaeus) infesting poplar trees in nursery plantings. In these tests he found that carbolineum painted upon the trees undiluted and in an emulsion form gave a good kill of the larvae, provided it was applied before the insects matured and bored into the heartwood for pupation.

During the summer of 1921 the writer, while located at the University of Maryland, prepared and tested a solution of para-dichlorobenzene dissolved in soluble pine tar creosote, against a specie of engraver beetles infesting growing pine trees. The material was prepared by dissolving para-dichlorobenzene at the rate of 1 pound in 1 quart of soluble pine-tar creosote. This was diluted with equal parts of water and sprayed upon the trunks of the infested trees. All stages of the insects were present. Some of the newer entrance holes, made by the beetles burrowing into the bark to lay their eggs, were closed or partially closed with rosin exuding from the bark. An examination made a week or ten days after applying the spray material showed an excellent penetration of the pine tar and para-dichlorobenzene and a kill of all stages of the insect. Considering the difficulty with which the pine-tar mixture penetrated the burrows, because of the rosin, excellent results were obtained.

Howard, in 1922, reports the use of para-dichlorobenzene dissolved in kerosene against boring insects infesting cut logs. This material, however, was used on cut timber and not on live trees.

The writer has been interested in the use of para-dichlorobenzene dissolvd in pine-tar creosote ever since he used it against pine bark beetles in Maryland. The pressure of other work, however, has prevented his continuing this investigation. During the summer of 1925 an opportunity was presented for testing it against larvae of *Euzophera semifuneralis* Walker boring in the bark of linden trees and in the summer of 1926 against the larvae of the mottled poplar and willow borer (*Cryptorhynchhus lapathi* Linn.) infesting pussywillows. The tests have not been extensive in number but the results obtained have been so promising that they are presented here to render the information available for others who might have an opportunity of testing the combination of para-dichlorobenzene and pine-tar creosote.

Tests Against the Larvae of Euzophera semifuneralis Walk.

Early in September, 1925, the writer's attention was called to an infestation of larvae of *Euzophera semifuneralis* Walk., at Hackensack, infesting the trunks of linden trees from slightly below the ground level to a height of 15 feet or more on the larger limbs. They were found feeding on the dead and corky outer part of the bark, on the green inner part of the bark, and on the cambium layer. No evidence was noticed of their feeding on the woody tissues. The feeding of the larvae, in addition to the destruction of the bark and cambium layer, caused an extensive growth of cells in the region of the cambium layer. This growth pushed out the corky part of the bark, causing the bark to crack and show in ridges. Such growth of soft tissues on one of the most heavily infested trees was an inch or more thick. Larvae were found boring through and feeding upon the cells of the soft growth. This growth was cut out and the wound cleaned where it was most severe. The work of the larvae was very easily noticed on the trunks of the trees due to the borings pushed out from the burrows in the cracks and crevices of the bark. The larvae spun some silk wherever they went and the borings were held together to a considerable extent by this spinning of the silk.

---

[1] Matheson, Robert, 1915. Experiments in the Control of the Poplar and Willow Borer (*Cryptorhyuchus laputhi* Linn.). In *Jour. Econ. Ent.*, v. 8: 522-525.

The para-dichlorobenzene and pine-tar mixture was made by dissolving para-dichlorobenzene at the rate of approximately 1 pound to 1 quart of soluble pine-tar oil. The pine-tar oil was heated to about 120°F., at which temperature the para-dichlorobenzene chrystals dissolve quite readily. The pine-tar oil used was obtained from the Georgia Pine Turpentine Company, of New York City, and the sample tested went by the trade name of "Pineole Soluble." This material was an unfractioned distillate and cost 40 cents a gallon in gallon lots. The mixture was diluted by adding 1 part to 2 parts of water before spraying upon the trunks of infested trees.

The material was applied September 11 with a compressed air sprayer, three to four gallons of the diluted spray material being used for the trunks of the five infested trees.

Larvae in the shallow burrows began to squirm out very soon after the spray material was applied. They seemed to be in considerable pain and many of them dropped to the ground around the base of the tree. Death was not rapid as some were alive an hour or more after spraying. Larvae in the deeper burrows were probably not killed so rapidly since it must have taken some time for the pine-tar para-dichlorobenzene mixture to penetrate. Where the spray material got on the hands and face it produced a sharp, stinging or burning sensation.

The sprayed trees were examined September 23. The pine-tar and para-dichlorobenzene odor was still quite prevalent on the trunks. A very thorough examination failed to show a single live larva, or place where borings of the larvae were being pushed out through cracks or crevices in the bark, thus indicating that none of those near the surface were alive. Many dead ones, however, were found throughout all parts of the bark. The tar oil had penetrated to all places where the worms had bored in the bark or in the pithy growth caused by the presence of the larvae. In some cases it had followed the burrows for several inches. A considerable quantity of this pithy material was dug out on one of the worst infested trees and all the larvae in it had been killed. The trees were examined carefully to determine whether any injury had been caused to the live and growing bark. No injury could be noted at this time and apparently the mixture had penetrated only where the larvae had left borings in the wood and in the dead woody tissues.

Later reports from the county agent at Hackensack indicated that the trees were growing satisfactorily, and did not show any injury from the use of the spray mixture; no evidence of the larvae boring in the trunks was noticed.

Tests Against the Larvae of the Mottled Poplar and Willow Borer (Cryptorhynchus lapathi Linn.) in Pussywillow

The mottled poplar and willow borer belongs to the family *Curculionidae*. This species was imported from Europe about 1882 and has since become a considerable pest of poplar and willow trees, especially where the trees are grown for the basket industry. The injury is done principally by the larvae feeding and burrowing through the infested plants and, to a slight extent, by the adults feeding upon the young twigs. It has been reported quite frequently as injuring pussywillows grown for ornamental purposes.

A severe infestation on two clumps of pussywillow trees was reported June 21, 1926, in New Brunswick, N. J. Some of the para-dichlorobenzene and pine-tar mixture was prepared as mentioned for use against the borer in the linden trees. A limb about 2½ inches in diameter and 3 feet long and containing approximately 75 larvae was treated on June 22. The stock solution was diluted with 2 parts of water and painted on the limb with an ordinary paint brush, applying it thoroughly so as to allow a good opportunity for it to penetrate the burrows. An examination of a few of the burrows made about five minutes after painting the limb showed that the pine-tar oil had followed the burrows wherever the borings were in the burrow. The burrows were from ⅛ to ¼ inch in diameter and most of them extended upward usually from ¾ to 1½ inches. Some of the larger larvae were getting ready to pupate and had bored into the wood at the top of the burrows.

A final examination of the treated limb was made on July 5. Three live pupae and one live full grown larva were found. All of these were in burrows extending toward the center of the heartwood.

Two infested pussywillow trees containing, probably, three or four hundred larvae were treated June 23. The owner of the trees misunderstood the dirctions and applied the material undiluted. An examination seven days after applying the material showed four or five places where borings were being pushed out. These places were repainted and a later examination failed to show any live larvae. No injury of the living wood on the trees could be noted from the application of the undiluted material.

The tests reported above were all conducted in severe infestations where a thorough test of the material was obtainable. No injury to the trees was noted, even where the material was used undiluted. Further tests will be conducted, as opportunity presents itself, to determine dilutions which will give effective control.

Investigations of Dusts, Spreaders, Stickers and Diluents for Spraying and Dusting Mixtures

Chemical Studies of the New Jersey Dry-Mix Spray in Relation to Arsenical Injury

JOSEPH M. GINSBURG

Introduction

Although the sulfur-lime dry-mix spray has proved to be a satisfactory substitute for self-boiled lime-sulfur and lead arsenate in its insecticidal and fungicidal values, it frequently causes arsenical burning on peach and apple foliage. Sufficient data have accumulated from previous investigations to warrant the conclusion that the injury is brought about by the water-soluble arsenic formed on the sprayed leaf surface, but the processes involved in the decomposition of the comparatively insoluble lead arsenate of the spray mixture into more soluble forms when applied on the leaf surface are not yet well understood. The prevailing conception among investigators in this field seems to be that arsenical burning is much more pronounced under prolonged humid conditions, high temperature, and intense sunlight.

It has not been proved, however, that these atmospheric factors singly or combined are of any significance in actually increasing the quantity of soluble arsenic. Furthermore the role that each one of the different ingredients of the "dry-mix"; namely, sulfur, lime, and "Kayso" plays, in decomposing the lead arsenate has not been definitely established. It was, therefore, deemed necessary to study this problem from these two angles in order to throw some light on the chemical processes involved. Accordingly, the investigations here reported embody three separate experiments. One includes a study of the influence of various atmospheric conditions on the formation of water-soluble arsenic. In the second experiment the effect of the different ingredients of the dry-mix on the decomposition of the lead arsenate was studied, while the third experiment consisted of testing other suitable correctives as substitutes for hydrated lime.

The Influence of Moisture, Temperature and Sunlight on the Formation of Water-Soluble Arsenic

Two extremes in each one of the three metereologic factors involved, corresponding generally to the mimimum and maximum conditions met with in the field during the growing season, were selected; namely, dry and moisture-saturated atmosphere; bright light and total darkness; and 80° and 100° F. In order to proximate field conditions, where the spray material remains on the leaf surface as a thin film, the sulfur-lime-arsenic mixture was spread in thin layers on glass plates and exposed to the desired atmospheric conditions for 8 days. At the end of this period the amounts of water-soluble arsenic formed on the plates were quantitatively determined. Weighed quantities of sulfur-lime-Kayso mixture, and accurately weighed samples of lead arsenate were transferred to the glass plates. The ingredients were thoroughly mixed, made into a paste with distilled water and spread evenly over a marked area on the plate. The chemicals and the amount of water were exactly in the same proportion as ordinarily present in the 4-8-50 dry mix. It was also found that 20 cc. of the spray mixture, containing a total of 0.6644 gm. of dry material, was sufficient for chemical analysis and could be conveniently spread in a thin layer on an area of 80 square inches. The glass plates used were 10 by 12 inches, and an area of 8 by 10 inches was marked off on the unsprayed side with wax-pencil. This left a margin of 2 inches to prevent any loss of liquid due to possible surface run off.

The following method was used in determining water-soluble arsenic. The material was carefully washed off from the plate into a porcelain dish with the aid of a rubber policeman, transferred to a 1-liter pyrex flask and the volume made up to 500 cc. with distilled water. The flasks were allowed to stand at room temperature with frequent shaking for 24 hours and filtered until a clear filtrate was obtained. The rest of the procedure was identically the same as that outlined by the Association of Official Agricultural Chemists. (2).

For that part of the experiment where no light was required the plates were placed in electric ovens adjusted with thermostats to control the temperature. When a dry atmosphere was desired, shallow dishes filled with fresh calcium chloride were placed in the oven and changed every day. In order to maintain an atmosphere saturated with moisture a large pan of water was placed on the bottom of the oven into which strips of cheesecloth, hanging down from a perforated plate near the roof of the oven and extending along the sides, were immersed. In this manner the atmosphere was kept saturated to the dew point as was indicated by drops and streams of water collecting on the sides of the oven. An open lot near the greenhouse, where sunlight had full access throughout the day, was selected for the experiment. Four plates were exposed to direct sunlight under the prevailing temperature, two of which were kept dry, while the other two were kept moist by spraying gently with distilled water every 30 minutes or as soon as they became dry. For this purpose some of the plates were perforated in the center and fastened in a horizontal position to wooden sticks extending 4 feet above the ground.

In order to test the combined effects of sunlight, moisture and high temperature, the following apparatus was improvised. A wooden box, without a top cover, about 1 foot deep and large enough to hold two glass plates was elevated to about 4 feet from the ground. A thermostat was then installed and connected up with electric wires from the greenhouse. The glass plates were lowered into the box and tightly fitted in at ½-inch from the top of the box on wooden planks, extending from the inside. In this manner the box was made practically air-tight so that it was possible to maintain constant temperature. By means of the thermostat and electric lamps, the temperature within the box was kept at 110°F. There being no outlet for the heat, it was absorbed by the glass plate and, of course, transmitted to the spray material closely adhering to its surface. In this manner the plates were submitted simultaneously to high temperature and direct sunlight. One of the plates was kept dry, while the other one was kept moist by atomizing it with distilled water. While spraying, the dry plate was covered to prevent any mist from settling on it. Since the apparatus could hold only two plates at the time, the experiment was run twice in order to obtain duplicate results.

Averages of duplicate analyses from each plate are presented in the tables, the percentage of water-soluble arsenic being based on the quantity of $PbHAsO_4$ (0.0712 gm.) present in the sample of dry-mix and calculated as As_2O_5.

The results do not reveal any appreciable differences in the amounts of water-soluble arsenic found on the glass plates which could be directly attributed to any one of the three atmospheric factors studied or to any one of their combinations. On the other hand, it appears that by merely spreading the spray material in a thin layer on a large surface and exposing it to the atmosphere, considerably higher amounts of water-soluble arsenic are formed than in the checks. Furthermore, no differences were found in the amount of soluble As_2O_5 obtained from plates kept for only 24 hours at room temperature and those exposed for 8 days to various combinations of temperature, humidity and light. This is of significance because it indicates that a comparatively short time is required for the chemical reactions, which liberate soluble arsenic in this mixture, to reach equilibrium.

While the results from these investigations, as seen from table 1 have definitely shown that high humidity, sunlight and high temperature play no role in the formation of water-soluble arsenic from $PbHAsO_4$ in the sulfur-lime mixture, the question still remains why foliage burning is more severe under these atmospheric factors. Accepting the theory that soluble arsenic is the agent responsible for the burning, these results point directly to physiological factors rather than to chemical agents responsible for excessive burning. That the permeability and absorbing powers of living protoplasmic tissue are affected by environmental conditions, and particularly by the very meterologic factors studied in these experiments, has been well established. High temperature increases the rate of diffusion of dissolved substances through the protoplasmic membrane and naturally would result in high absorption of soluble arsenic through the stomata and lenticels, or cuticle. Furthermore, a long period of high temperature will reduce the turgidity of the plant tissue, because of excessive transpiration, and weaken its resistance to penetration of poisonous substances. It is generally observed that under prolonged humid conditions, the internodes are long, and the leaf blades extensive and covered with a thin cuticle. All these characteristics would result in low resistance of the plant to the penetration of toxic substances.

It appears, therefore, from these investigations that the role which atmospheric conditions play in arsenical injury to foliage is primarily a problem of plant physiology and specifically of changes in plant permeability, rather than of pure chemistry. Further experiments, however, on the permeability of plants to soluble arsenic under different climatic conditions are necessary in order to establish definitely the truth of this assumption.

TABLE 1

Water-Soluble Arsenic Found on Plates Covered With Spray Mixtures Exposed for 8 Days to Darkness and Sunlight Under Varying Conditions of Moisture, Light and Temperature

Plate No.	Treatment	As_2O_5		
		Series 1	Series 2	Average
		per cent	*per cent*	*per cent*
1, 2	80°F., moisture, dark	6.30	6.02	6.16
3, 4	80°F., dry, dark	6.32	5.60	5.96
5, 6	110°F., moisture, dark	6.02	6.36	6.19
7, 8	110°F., dry, dark	6.12	6.36	6.24
9, 10	Sun, dry, ordinary temperature	6.58	6.62	6.60
11, 12	Sun, moist, ordinary temperature	6.40	6.78	6.54
13, 14	Sun, dry, 110°F.	6.49	6.73	6.61
15, 16	Sun, moist, 110°F.	6.24	6.72	6.48
17, 18	Room temperature for 24 hours	5.72	5.96	5.84
19, 20 (Check)	0.6644 gm. of spray mixture shaken for 24 hours, in 500 cc. of distilled water	3.58	3.80	3.69
21, 22 (Check)	0.0712 $PbHAsO_4$ shaken for 24 hours in 500 cc. of distilled water	0.82	0.90	0.86

The Influence of Hydrated Lime, Kayso and Sulfur on the Formation of Water-Soluble Arsenic

Samples of lead arsenate were mixed with weighed quantities of hydrated lime, sulfur and Kayso separately; hydrated lime and sulfur; hydrated lime and Kayso; sulfur and Kayso; and finally with all the three ingredients corresponding to the complete spray. These combinations resulted in eight different mixtures, including lead arsenate alone used as a check. The salts were weighed separately into glass bottles, thoroughly mixed and 100 cc. of distilled water, previously freed from CO_2, was added. The mixtures were kept at room temperature for six days, with frequent shaking, and then diluted to 500 cc. with distilled water and allowed to stand over night. At the end of this period water-soluble arsenic was determined by the official methods (2) and reported as As_2O_5, the percentages being based only on the amount of $PbHAsO_4$ present in the mixtures. The quantities of the different ingredients were equal to those present in 100 cc. of spray when 1½ pounds of lead arsenate were used, namely, 1.84 gm. sulfur, 0.92 gm. hydrated lime, 0.356 gm. lead arsenate and 0.115 gm. Kayso. All the chemicals with the exception of $Ca(OH)_2$, which was chemically pure, were commercial brands used on the college orchard. A period of 6 days was selected because preliminary experiments have shown that this time is sufficient for the reactions which take place in the arsenic-sulfur-lime mixture to reach equilibrium at room temperature.

TABLE 2

Water-Soluble Arsenic Obtained from Acid Lead Arsenate When Mixed With Hydrated Lime, Kayso and Sulfur, and Kept for Six Days at Room Temperature

Mixture No.	Composition	As_2O_5		
		Series 1	Series 2	Average
		per cent	*per cent*	*per cent*
1 (Check)	$PbHAsO_4$	2.45	2.80	2.63
2	$PbHAsO_4$, $Ca(OH)_2$	0.74	1.07	0.91
3	$PbHAsO_4$, Sulfur	2.67	2.88	2.72
4	$PbHAsO_4$, Kayso	6.43	7.15	6.79
5	$PbHAsO_4$, $Ca(OH)_2$, Sulfur	0.57	0.76	0.67
6	$PbHAsO_4$, $Ca(OH)_2$, Kayso	0.91	0.83	0.87
7	$PbHAsO_4$, Sulfur, Kayso	6.67	8.25	7.46
8	$PbHAsO_4$, $Ca(OH)_2$, Sulfur, Kayso (Complete sulfur-lime dry-mix spray)	0.57	0.78	0.67

A comparison of the data from the chemical analyses shows that hydrated lime reduced the per cent of water-soluble arsenic from 2.63 found in the check to 0.91 when added alone to the lead-arsenate and to 0.67 when added mixed with sulfur. On the other hand, the presence of "Kayso" released more than twice the amount of soluble As_2O_5 (6.79 per cent) found in the check. Similar increases in soluble arsenic were also observed in mixture 7, where both Kayso and sulfur were added. Sulfur in itself, however, has not appreciably affected the decomposition of $PbHAsO_4$ as may be seen from mixture 3. The fact that Kayso liberated such large quantities of soluble As_2O_5 was rather surprising at first but upon further testing it was found to contain considerable quantities of calcium carbonate. It was, therefore, suspected that the $CaCO_3$ was responsible for the above reaction. This assumption was beautifully confirmed by the following experiment the results of which are presented in table 3.

Several 100-cc. mixtures were prepared and submitted to the same treatment as described above, with the exception that Kayso was replaced by equal amounts of calcium carbonate, or skim-milk, or casein. The per cent of water soluble arsenic from mixture 9, where $CaCO_3$ was used was even greater than that obtained in the presence of Kayso (mixture 4 and 7). On the other hand, the addition of skim-milk or casein to either lead arsenate alone or to lead arsenate mixed with sulfur decreased considerably the amount of As_2O_5 as compared with that found in the check. That skim-milk prevents the formation of soluble arsenic from acid lead arsenate has been observed also by Thatcher and Streeter (4) in their studies of the lime-sulfur spray. These results suggest that Kayso may furnish a source of $CaCO_3$ and that skim-milk, or some other casein preparation not containing lime, could be used more advantageously as a spreader. Considering the chemical composition of the spray, the following reaction suggests itself:

$$PbHAsO_4 + CaCO_3 = PbCO_3 + CaHAsO_4$$

This reaction explains why so much more water-soluble arsenic was obtained when calcium carbonate was used. In the presence of this salt the soluble monocalcium arsenate and the very insoluble lead carbonate are formed. Of course, this reaction is only suggestive and further studies are required definitely to establish it.

TABLE 3

Water-Soluble Arsenic Obtained from Acid Lead Arsenate Mixed With Calcium Carbonate, Skim-Milk, and Casein, Kept for 6 Days at Room Temperature

Mixture No.	Composition	As_2O_5		
		Series 1	Series 2	Average
		per cent	*per cent*	*per cent*
9 (Check)	$PbHAsO_4$	2.12	2.29	2.20
10	$PbHAsO_4$, $CaCO_3$, Sulfur	7.17	9.32	8.25
11	$PbHAsO_4$, Skim-Milk	1.20	1.05	1.13
12	$PbHAsO_4$, Casein	1.20	1.11	1.16
13	$PbHAsO_4$, Sulfur, Skim-Milk	1.20	1.32	1.26
14	$PbHAsO_4$, Sulfur, Casein	1.27	1.27	1.27

Arsenical Burning and Correctives

Lime has been universally used as a "corrective" for arsenical injury in both dust and liquid mixtures. Hydrated lime is at present being used in the New Jersey dry-mix as a corrective. Frequently, however, appreciable burning occurs on peach and apple foliage, especially on the former, even in the presence of $Ca(OH)_2$. From the results mentioned above and from the work of Campbell (1) and Mogendorf (3) at this station, it appears that the $CaCO_3$ formed from the hydrated lime is responsible for the liberation of water-soluble arsenic. Since carbonation of the $Ca(OH)_2$ cannot be avoided under atmospheric conditions an attempt was here made to find a substitute for hydrated lime which should take up the soluble arsenic present in the spray mixture without reacting with the lead arsenate.

Guided by this principle a number of salts of the weaker bases, as well as some organic colloids, were selected for testing. Since spreading the spray mixture on large surfaces has proved to be a more severe test for the formation of water-soluble arsenic, this method was adopted for the succeeding experiments. For this purpose samples of 20-cc. spray mixtures were prepared by the method described above with the exception that the $Ca(OH)_2$ of the dry-mix was replaced by either 4 or 8 pounds of the chemical to be tested, and powdered skim-milk was substituted for Kayso in equal quantities. The mixtures were spread on large petri dishes and kept at 100° F. The plates were atomized every morning with distilled water until the material was quite wet in order to obtain the effect of alternate wetting and drying brought about in the field by the morning dew. At the end of this period water-soluble arsenic was determined. Out of some eighteen chemicals tested the oxides of zinc, iron and aluminum and charcoal formed less soluble As_2O_5 than equal quantities of hydrated lime. Zinc oxide proved to be best of all. When only two pounds of this compound were used the amount of soluble As_2O_5 was less than half of that obtained with 4 pounds of $Ca(OH)_2$, while with 8 pounds of zinc oxide no soluble As_2O_5 could be detected. These results were very encouraging and further tests were carried out. In all these experiments the Zinc Oxide stood the test well and never failed to eliminate the soluble arsenic from solution.

Of course, the next logical step was to test out the behavior of the Zinc Oxide on plants. The season of the year not permitting outdoor work, lima beans were grown in the greenhouse and sprayed with the following three mixtures. One group of plants was sprayed with lead arsenate alone; another one was sprayed with a mixture of lead arsenate, sulfur and skim-milk; while the third one received the complete dry-mix spray containing 4 pounds of zinc oxide instead of hydrated lime.

In each case where no zinc oxide was used decided arsenical burning developed six days after the spray was applied, whereas no injury whatsoever was observed on plants from group 3. Two weeks after the first application the spraying was repeated with the result that plants from groups 1 and 2 were badly injured. The burning was especially severe where lead arsenate alone was used, as may be seen from plate 1. On the other hand, the plants sprayed with zinc oxide appeared healthy and normal in every respect, exhibiting no injury whatsoever. The injury appeared in the form of large, brown blotches on the leaf surface and along the edges which later developed into dead tissue. Thus, the results from both laboratory and greenhouse experiments with zinc oxide were encouraging and tempted us to proceed with these investigations in the orchard on a somewhat larger scale. From the physical standpoint zinc oxide is in no way inferior to lime and even possesses greater adhesive properties when sprayed on foliage.

The field experiments were carried out on the College orchard and on the Del-Bay Farms, Bridgeton, in cooperation with the department of pomology. Apple and peach trees were sprayed with the New Jersey dry-mix in which the hydrated lime was replaced by 2 pounds and 4 pounds of zinc oxide, respectively. The results were rather surprising and contrary to expectations. Injury was observed on peach and apple foliage 7 days after the zinc oxide spray was applied. This was later accompanied by severe burning and heavy defoliation. The nature of the injury was somewhat different from that caused by lead arsenate and suggested a distinct zinc oxide burning. This assumption was later confirmed by a separate experiment in which peach and apple trees were sprayed with zinc oxide alone in concentrations of 1, 2, 3, and 4 pounds to 50 gallons of water. Foliage injury was pronounced with 1 pound of zinc oxide and increased in severity when higher concentrations were used. Where 3 and 4 pounds of zinc oxide were applied the defoliation on both peach and apple trees was particularly noticeable, amounting to 20 per cent of the total number of leaves on some of the trees.

Further observations disclosed the fact that the symptoms of zinc oxide burning are quite distinct and may be recognized by the following characteristics. On apple trees, yellow spots appeared, 7 to 10 days after the spray was applied, on both sides of the leaf near the midrib and gradually spread throughout the leaf tissue and petiole. Often the entire leaf became yellow and dropped off. The burned leaf tissue remained intact and no breaking away of the injured parts, nor brown, dead spots, were noticeable. On peach foliage the injury was somewhat similar to that caused by lead arsenate with the exception that it occurred sooner and was more severe. The leaf became gradually covered with brown spots specially near the edge which later developed into strips of dead tissue.

In view of this unfavorable development zinc oxide had to be discarded from practical use and recourse was made to the other chemicals that gave promising results in the laboratory. Experiments are at present conducted on peach and apple trees with ferric oxide, aluminum oxide, and charcoal. While no injury to plants has been so far observed from any one of these compounds when used as substitutes for hydrated lime in the dry-mix spray, the work has not advanced far enough to permit any definite conclusions.

PLATE 1

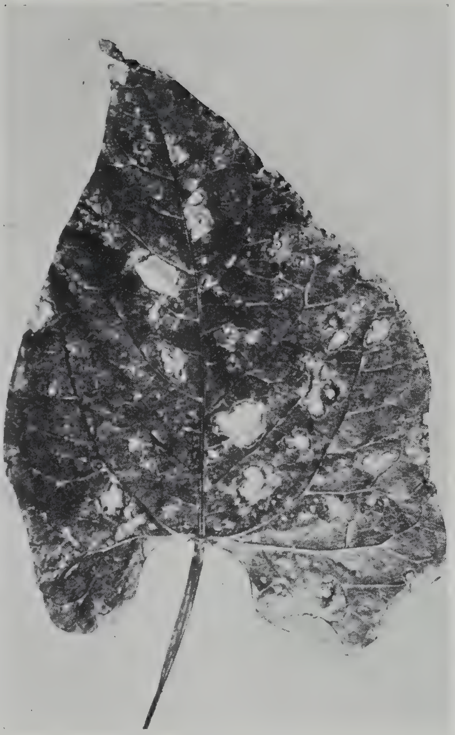


Fig. 1. Leaf from Lima Bean Plant Sprayed With Lead Arsenate Only, White Blotches Indicating Arsenical Injury

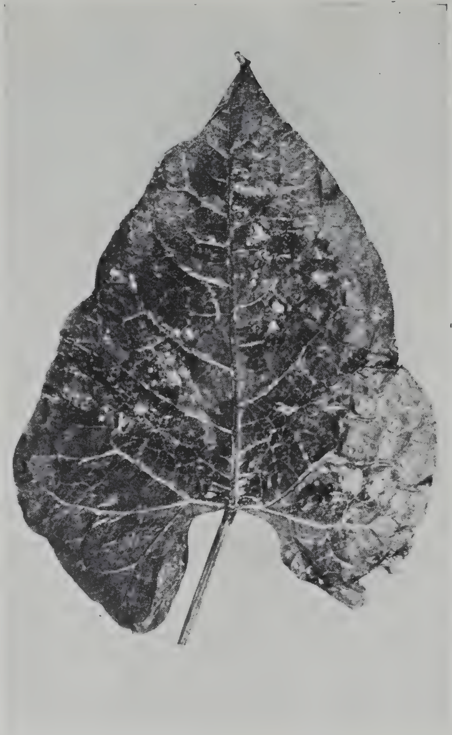


Fig. 2. Leaf from Lima Bean Plant Sprayed With Lead Arsenate, Sulfur and Skim-Milk

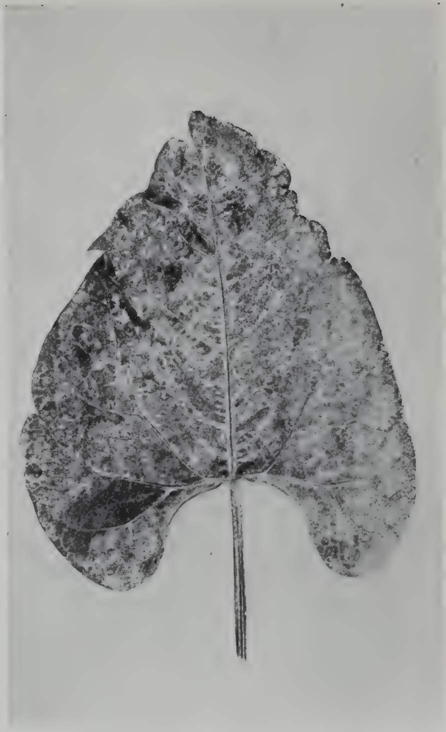


Fig. 3. Leaf from Lima Bean Sprayed With Lead Arsenate, Sulfur, Skim-Milk and Zinc Oxide

(*Facing page* 204)

TABLE 4

Water-Soluble Arsenic Found on Glass Plates Covered With New Jersey Dry-Mix Spray Containing Various Substitutes for $Ca(OH)_2$

Plate No.	Corrective	As_2O_5	Adhesion
		per cent	
1	4 pounds Aluminum Oxide	2.29	good
2	8 pounds Aluminum Oxide	1.75	good
3	4 pounds Aluminum Palmitate	2.01	poor
4	8 pounds Aluminum Palmitate	1.40	poor
5	4 pounds Aluminum Tannate	8.26	fair
6	8 pounds Aluminum Tannate	12.12	fair
7	4 pounds Kaolin	3.16	poor
8	8 pounds Kaolin	2.64	poor
9	4 pounds Aluminum Silicate	13.34	poor
10	8 pounds Aluminum Silicate	11.77	poor
11	4 pounds Bauxite	3.16	fair
12	8 pounds Bauxite	lost	——
13	4 pounds Ferric Oxide	2.10	good
14	8 pounds Ferric Oxide	1.40	good
15	4 pounds Ferric Oxide (dialized)	1.05	good
16	8 pounds Ferric Oxide (dialized)	1.23	good
17	4 pounds Calcined Alumina	2.64	fair
18	8 pounds Calcined Alumina	2.64	fair
19	4 pounds Stannous Oxide	3.16	good
20	8 pounds Stannous Oxide	3.16	good
21	4 pounds Stannic Oxide	2.10	good
22	8 pounds Stannic Oxide	3.16	good
23	4 pounds Stannic Oxide, very fine	3.16	good
24	8 pounds Stannic Oxide, very fine	1.94	good
25	4 pounds Lead Oleate	3.86	very good
26	8 pounds Lead Oleate	6.00	very good
27	4 pounds Zinc Carbonate	2.80	good
28	8 pounds Zinc Carbonate	0.53	good
29	4 pounds Charcoal	2.30	fair
30	8 pounds Charcoal	0.75	fair
31	2 pounds Zinc Oxide	1.08	very good
32	4 pounds Zinc Oxide	0.48	very good
33	6 pounds Zinc Oxide	0.48	very good
34	8 pounds Zinc Oxide	0.00	very good
35 (Check)	4 pounds Hydrated Lime	2.80	good
36 (Check)	8 pounds Hydrated Lime	2.46	good
37 (Check)	None	3.87	fair
38 (Check)	Lead Arsenate only	3.91	very good

References

(1) Campbell, F. L. 1926 On the role of calcium hydrated lime acid-lead-arsenate spray. *Jour. Agr. Res.* 32:77.

(2) Methods of Analysis of the Association of Official Agricultural Chemists. 1925. Washington, D. C.

(3) Mogendorff, N. 1925 A study of the chemical factors involved in arsenical injury to fruit trees. N. J. Agr. Exp. Sta. Bul. 419.

(4) Thatcher, R. W. and Streeter, L. R. 1924 Chemical studies of the combined lead arsenate and lime sulfur spray. N. Y. Agr. Exp. Sta. Bul. 521.

Investigation of Stickers in Dusting Mixtures

JOSEPH M. GINSBURG

The advantage of dusting over spraying from an economical standpoint has already been treated in previous reports and no further discussion here is necessary. The main object in this study is to obtain a dust which will not be washed off readily and will stick to the foliage sufficiently long to kill chewing insects without injuring the plant tissue. The most difficult part of the problem is to hold the dust on the leaf surface during rainy weather. The work begun by Dr. Stinson was continued during the last year. Also new methods were developed in preparing the several dust mixtures which are at present being tested out in the field. In general, two lines of attack were followed. The first consisted of incorporating in the sulfur-arsenical dust mixture an insoluble substance which possesses great adhesive qualities. In the second method the dust is covered with a fine spray of a very viscous and sticky liquid such as oil. A special apparatus was devised and constructed for this purpose which is at present employed in preparing the dust.

Among the chemicals tested for sticking qualities to be incorporated in the dust, the soaps of heavy metals such as stearates, palmitates, and resinates of copper and zinc proved of particular value. These compounds possess great adhesion when tried on glass and foliage surfaces and can be prepared in the form of very fine, fluffy powders. They are also superior to the soaps of sodium and potassium in that they are very insoluble and do not react with the lead arsenate of the dust mixture, thus eliminating the possibility of forming soluble arsenic on foliage.

Oil Sprays and Emulsifiers

JOSEPH M. GINSBURG

Miscible Oils and Oil Emulsions

The problems of oil sprays came up in connection with red-mite control. Oil emulsions, applied as delayed dormant sprays, proved more efficient in killing the eggs of red mite than any of the other insecticides. It is not altogether clear, however, which kind of emulsion is most efficacious for this purpose. There are at present several oil emulsions and miscible oils on the market which differ both in the grade of oil and in the kind of emulsifying agent. Especially the difference in killing efficiency of miscible oils and oil emulsions was not well understood. Results from several investigators in this field show that, with equal oil concentrations, oil emulsions are far more effective than miscible oils in destroying red-mite eggs, yet the latter are more expensive.

Preliminary tests in the laboratory suggested that the emulsifying agent may be the chief factor responsible for these differences. Emulsions, therefore, were prepared from Diamond Paraffin Oil (a lubricating oil commonly employed in home-mixed emulsions) with different emulsifiers and the physical characteristics of the mixtures studied. The following emulsifying agents were used: potassium fish-oil soap, Rosin fish-oil soap, Cresoap, cresylic acid-fish-oil mixture, ammonium oleate, potassium oleate, glue, powdered skim-milk, egg albumin, gum arabic, powdered acacia, Kayso, casein, Bentorite, Wilkonite (colloidal clays), colloidal sulfur, calcium resinate, zinc resinate, copper resinate and lead arsenate. Most of these emulsifiers with the exception of cresylic acid-fish-oil mixture produce more or less stable stock emulsions if properly agitated. Upon dilution, however, distinct differences are observed in the mechanical behavior of the different mixtures. Roughly the emulsions obtained here can be divided into three groups: (1) emulsions which break up and liberate the oil immediately on the surface of the liquid, formed by the three resinates, colloidal clays and casein; (2) emulsions which release the oil gradually upon standing, obtained from the fish-oil soaps, skim-milk, egg albumin, etc.; (3) emulsions which do not liberate the oil and present a homogeneous mixture even at high dilutions,—obtained with proper manipulation from the oleates of ammonium and potassium.

An examination of a number of commercial oil sprays revealed similar characteristics. All of the miscible oils tested with the exception of one exhibited characteristics similar to those from group 3. They gave a milky mixture upon dilution which remained stable for a long time without forming an oily layer on the surface. Most of the oil emulsions tested resembled those of group 2, while only one behaved exactly like group 1 and quickly liberated its oil on the surface upon dilution. These differences were so pronounced that they at once became suggestive of being the possible causes of the differences observed in the killing efficiency of miscible oils and oil emulsions.

Commercial samples as well as laboratory prepared emulsions of each of the three groups enumerated above were tested out by Mr. Carl Ilg on apple twigs infested with red mite eggs. The stock mixtures were diluted with water so as to contain only 2 per cent of oil. The results of these tests have shown that in each case (with one exception) where the oil is gradually liberated on the surface of the liquid the highest percentage of kill was obtained, regardless of whether the spray was a miscible oil or an oil emulsion. On the other hand, the miscible oils, which did not liberate the oil at all upon dilution, but held it in permanent suspension, did not produce a satisfactory kill with the concentration used, whereas the oil emulsion which released its oil quickly upon dilution, such as the one prepared by the aid of colloidal clay, gave the poorest percentage of kill.

While these results in a way are preliminary, they suggest that the superiority of oil emulsions over miscible oils may be ascribed to the fact that the former release their oil gradually, depositing an oily layer on the sprayed surface, whereas the latter form more homogeneous mixtures and possibly prevent intimate contact between the oil and the sprayed surface. It is planned to continue the studies in this problem somewhat more extensively during the coming year in order definitely to establish the above observed phenomena.

Effect of Mineral Oil on Foliage

The application of oils as summer sprays against codling moth, Oriental peach moth, leaf roller and possibly other pests has recently attracted the attention of entomologists. The ordinary lubricating oils, however, cause severe damage to foliage and their application could not be considered at all. Some previous experiments at this station and the more extensive investigations in California indicate that the highly refined lubricating oils can be applied with comparative safety on fruit trees.

In order to study this problem under summer conditions prevailing in New Jersey two oils were tried out in the field, a light lubricating oil (Diamond paraffin) and a highly refined oil (Marcol). Peach trees were sprayed with skim-milk emulsions prepared from the two oils in concentrations ranging from 0.25 to 2 per cent oil. From the observations presented in table 1 it appears that the ordinary lubricating oil injured peach foliage in any one of the concentrations employed in this experiment and caused defoliation ranging from 10 per cent with the lowest concentration (0.25 per cent) to 90 per cent with the highest concentration (2 per cent) of oil. The injury from Marcol oil was only slight when compared with that of the lubricating oil, being not significant with concentrations below 5 per cent. With increasing concentrations however, the burning became more pronounced. These investigations are being continued further and other refined oils are being tested out, also the cumulative effect of oil sprays on fruit trees is being studied.

TABLE 1

Injury to Peach Foliage Sprayed With Ordinary Lubricating Oil and Refined Oil in Varying Concentrations

Refined Oil				Lubricating Oil			
Oil Concentration	Date Sprayed	Injury Observed	Nature of Injury	Oil Concentration	Date Sprayed	Injury Observed	Nature of Injury
per cent				*per cent*			
0.25	6-9	—	none	0.25	6-9	6-12	About 10 per cent leaf drop
0.50	6-9	—	none	0.50	6-9	6-11	Over 10 per cent leaf drop
0.75	6-9	6-20	very slight	1.75	6-9	6-11	40 per cent leaf drop
1.00	6-9	6-14	some leaf drop	1.00	6-9	6-11	50 per cent leaf drop; fruit drop
1.50	6-9	6-13	leaf drop considerable	1.50	6-9	6-11	70 per cent leaf drop; heavy fruit drop
2.00	6-9	6-13	Appreciable leaf drop	2.00	6-9	6-11	90 per cent leaf drop; 100 per cent fruit drop

The refined oils are primarily distillates from which the unsaturated hydrocarbons of the olefine series as well as those of the aromatic series have been removed by a process of sulfonation. They consist mainly of the saturated hydrocarbons of the paraffin series. While the causative agent of oil injury has not been established, the fact that the highly refined oils are very much less toxic to foliage than are the unrefined oils suggests that either the unsaturated or the aromatic hydrocarbon may be responsible for foliage burning.

A Study of the Fundamental Principles Influencing the Spreading, Adherence, and Distribution of Arsenical Sprays

C. C. HAMILTON

This project has been under investigation for almost a year. The work thus far has consisted entirely of laboratory work under controlled conditions, whereby any one of several factors can be varied and its results noted. Although the work has progressed satisfactorily and a considerable amount of time has been devoted to this subject, definite conclusions cannot be stated at this time.

The Distribution, Quantity and Adherence of Lead Arsenate Deposited in Field Spraying and Their Relation to Twig and Leaf Growth

C. C. HAMILTON

Considerable work has been done by different investigators relative to the quantity of lead arsenate deposited upon sprayed fruit and foliage. These results have been quite varied and not at all consistent. The purpose of the work outlined in this paper was to get data upon some of the factors having a bearing upon studies being conducted upon the quantity, distribution, and adherence of lead arsenate sprays. The several points which it was thought desirable to investigate were: (1) the relation of the development of the twig and leaf growth to the dates of spraying; (2) the quantity of lead arsenate on the lower and upper parts of sprayed trees at the dates of spraying; (3) the quantity of lead arsenate on the foliage immediately before and following each spray application; and (4) the quantity of lead arsenate, at the end of the spraying season, on the foliage developing between the different dates of spraying.

The work was done in a commercial orchard at Moorestown, N. J. A block of trees was used for demonstration spraying by the extension specialist in fruit growing and by the associate county agent of Burlington County. The remainder of the trees were sprayed by men in the employment of the owner of the orchard. Samples of sprayed foliage were collected from two varieties of trees, Rome Beauty and Stayman, in the demonstration sprayed block and in the orchard sprayed block. Collections were made immediately preceding and following each spray application on the following dates: May 7, May 19, June 4, and June 23. Leaves were taken from entire twigs in collecting the samples. Some of the leaves were pressed and dried between herbarium paper and other samples were placed in paper bags.

About one hundred twigs were tagged, to obtain the data on the twig and leaf growth, and the total twig length and number of leaves were noted at each date of spraying. At the end of the spraying season, just previous to the Japanese beetle spray, these tagged twigs were collected and the leaves developing between the spray application were separated into groups and analyses were made to determine the quantity of lead arsenate per unit of leaf area. A total of 300 to 1,000 square inches of leaf surface was used in most of the analyses. Each point in the charts represents an average of 6 to 8 such analyses. The individual analyses varied considerably, but by taking an average of a number of analyses the results presented should be fairly representative.

The Development of Twig and Leaf Growth at the Different Dates of Spraying

In this part of the work twigs were tagged and the total length and number of leaves developed at each spray application noted, as previously explained. The tagged twigs were located on both the lower and the upper parts of the trees; and fruit spurs, leaf spurs and twigs with terminal growth were tagged. The fruit and leaf spurs were not included in the results recording the twig growth, since the growth made was exceedingly small and was practically completed by the time the first measurements were made on May 7. The writer arrived in New Jersey shortly after the first of May. For this reason it was not possible to start the work at the beginning of twig and leaf growth. He has, therefore, taken April 15, which is about one week earlier than the average blooming date for apples, as the date when twig and leaf growth may be expected to start.

Figure 8 shows the per cent of the total twig and leaf growth at the different dates of spraying. The first part of the graph *A*, shows the per cent of leaf growth in numbers for the upper and lower parts of the trees. The number of leaves appearing early in the season on the lower part of the trees is greater than on the upper part. This is probably due to the greater number of fruit spurs tagged on the lower part of the trees, which obtain most of their leaves quite early. On the other hand, the terminal twigs on the upper part of the tree continue to grow later than those on the lower part, thus adding new leaves. The second part of the graph *B*, shows the relation between twig growth on the lower and upper parts of the trees.

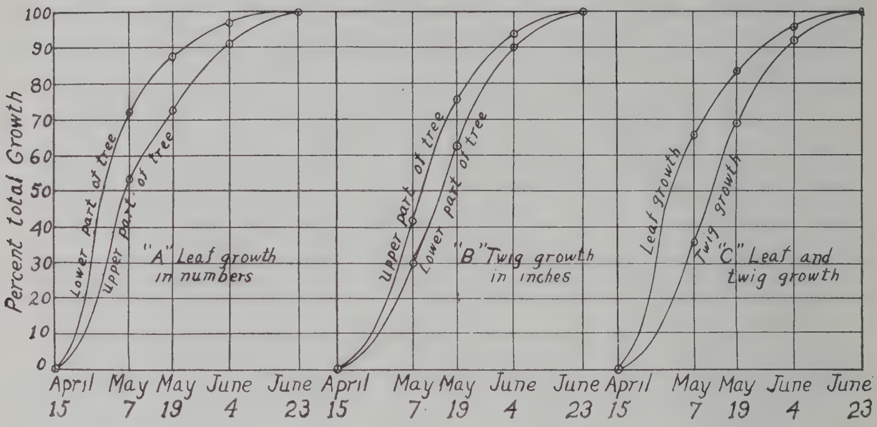


FIG. 8. THE DEVELOPMENT OF TWIG AND LEAF GROWTH AT THE DIFFERENT DATES OF SPRAYING

Since the fruit spurs have been omitted there is not as great a discrepancy as occurred in the development of the leaves and the growth is distributed more evenly throughout the entire season. The third part of the graph *C* compares the leaf growth in numbers with the twig growth in inches, taking an average of both the lower and the upper parts of the trees. This shows that a total of 66 per cent of the leaves have developed by May 7, while only 35 per cent of the total twig length has developed on this date. It was noticed, however, that while the greatest number of leaves had developed previous to May 7, the leaf area increased proportionally more rapidly between May 7 and May 19 than is indicated, because of the increase in the size of the leaves.

Quantity of Lead Arsenate Upon Foliage Collected at Different Dates of Spraying

It was thought that the quantity of lead arsenate per unit of leaf area on the foliage as a whole would increase as the spraying season advanced, because of the successive applications of spray material. This, however, did not prove to be the case. Figure 9 shows the quantity of lead arsenate in milligrams per 10 square inches of leaf surface. This has been presented to show: *A* the relation between the quantity on the lower and the upper part of the sprayed trees, *B* the difference in quantity on the foliage before and after spraying, and *C* the difference in the quantity between the demonstration spraying and the orchard spraying.

These data show that the quantity of lead arsenate per unit of leaf area decreased as the spraying season advanced up to June 4 when it rose rapidly.

This can be explained by referring to figure 9, showing the twig and leaf growth, in which we find that leaf growth and leaf area increased very rapidly up to June 4. It is evident that this rapid increase in leaf area more than offsets any accumulation of lead arsenate, due to successive sprayings. After the leaf growth slowed up, the quantity of lead arsenate per unit of leaf area began to rise. It will also be noticed that considerably more lead arsenate was deposited on the lower part of the trees than on the upper part. On the other hand, there was not as much difference in the quantity of lead arsenate on foliage collected just before and immediately following sprayings as was expected. These data also show that considerably more lead arsenate was deposited on the foliage in the demonstration-sprayed block than in the orchard-sprayed block, except for the collections made on June 4.

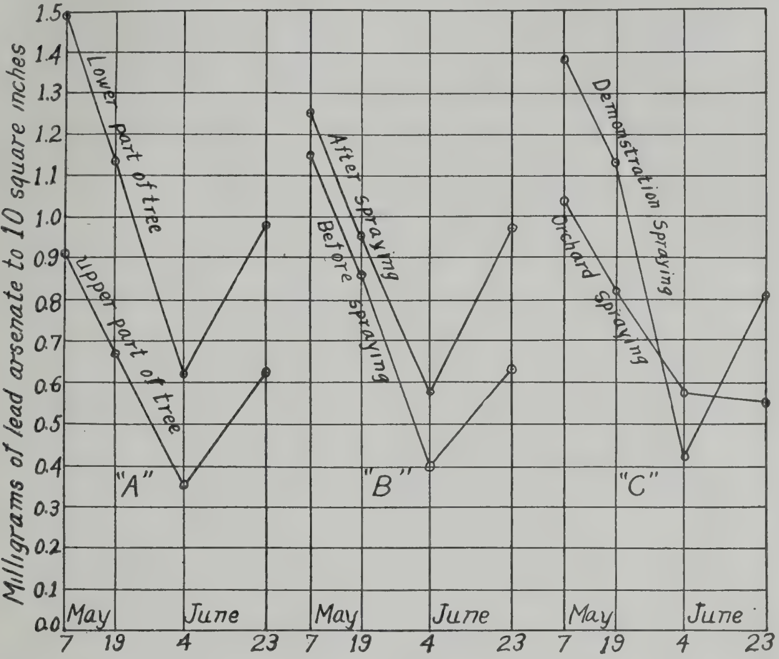


FIG. 9. THE QUANTITY OF LEAD ARSENATE ON APPLE FOLIAGE AT THE DIFFERENT DATES OF SPRAYING

The Quantity of Lead Arsenate on the Foliage Developing Between Spray Application

The leaves on the twigs which were tagged to obtain data on the twig and leaf growth were separated, according to the dates of development, corresponding with dates of spraying, and analyses made to determine the quantity of lead arsenate. The leaves developing previous to May 7, at the end of the season, had received four and some five spray applications. Those developing between May 7 and 19 received three applications, those between May 19 and June 4 two applications, and those developing between June 4 and 23 one application of spray material. The data showing the results of the analyses are presented in figure 10. At the end of the season leaves developing

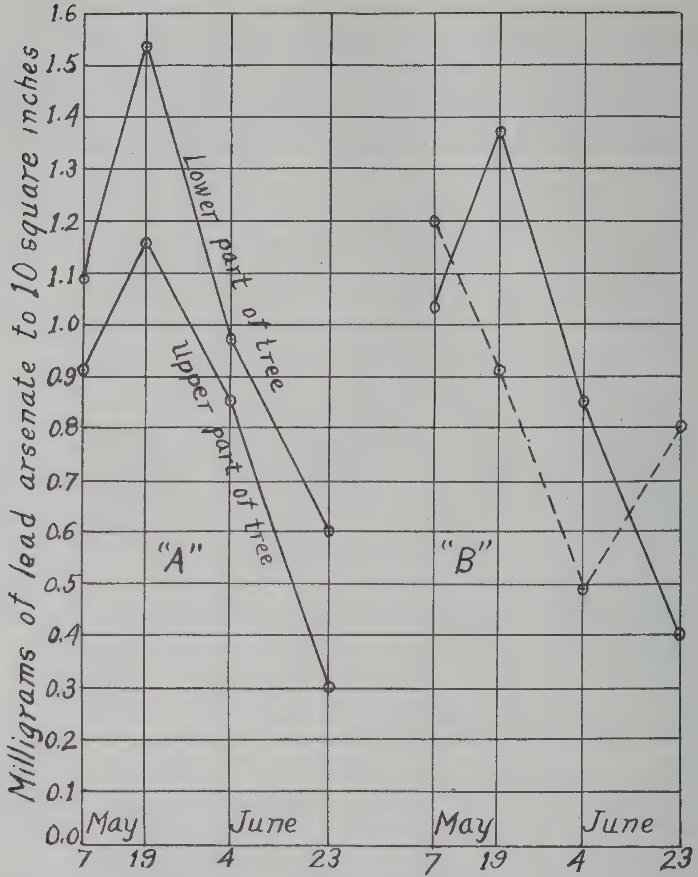


FIG. 10. *A*, THE QUANTITY OF LEAD ARSENATE ON APPLE FOLIAGE DEVELOPING BETWEEN THE DATES OF SPRAYING; *B*, SOLID LINE, AN AVERAGE OF THE QUANTITY OF LEAD ARSENATE DEVELOPING BETWEEN THE DATES OF SPRAYING; BROKEN LINE, AN AVERAGE OF THE QUANTITY OF LEAD ARSENATE ON THE FOLIAGE COLLECTED AT THE DIFFERENT DATES OF SPRAYING

previous to May 7 did not have as much lead arsenate per unit of leaf area as those developing between May 7 and 19. After May 19 the quantity per unit of leaf area fell rapidly as was expected. Figure 10 also shows the average of the quantity of lead arsenate on foliage collected at different dates of spraying, plotted with the quantity of lead arsenate on the foliage developing between the different dates of spraying. The graphs, each point of which represents an average of 16 analyses, are almost exact opposites to each other. I am, at this time, unable to explain the smaller quantity of lead arsenate on foliage developing previous to May 7.

The importance of this work may be realized if one is taking samples at different times during the spraying season to determine the quantity of lead arsenate on the foliage at any given time. One must take into consideration their location on the tree, the age of the leaves and the increase in leaf area between the different dates of spraying.

Small Fruit Insect Investigations

The Raspberry Crown Borer

This insect is known by the common name of the raspberry root borer, but its habit upon raspberry, wherever its work has been observed in New Jersey, is such as to indicate that it is really a crown borer. It is of large economic importance in the immense raspberry growing territory in the vicinity of Hammonton, N. J.

During the year just closed a study was made of this insect. This study has indicated distinctly that the raspberry crown borer is annual brooded; that pupation occurs from the middle of August to the middle of September; that emergence of the moths occurs between the end of August and the end of September; that eggs begin to appear, always on the under-sides of leaves, during the first week in September, reach their maximum and cease to appear about the end of that month; that eggs begin hatching about the middle of September and cease by the middle of October; that the newly hatched larvae crawl down the canes to a point just below the surface of the ground, where each proceeds to cut a shallow cell in the side wall of the cane, erecting over this cell a cover, consisting of pieces of bark held together by silk; that within these blister-like chambers the larvae pass the winter; that larvae emerge from these blisters about the middle of April and bore channels in the bark of the lower part of the cane, giving especial attention to the point where the new shoots start out from the old canes.

The studies of insecticides indicate that calcium cyanide has too narrow a margin of safety between the dosage which will kill the borer and the dosage which will damage the plants to render it a satisfactory insecticide. Carbon bisulfide has a slightly wider margin of safety, but is disqualified for the same reason. Tobacco dust, on the other hand, has a wide margin of safety between the dosage which will kill the insect and the dosage which will hurt the plant. These studies have shown that the most practical time to kill this insect is when it has established its blister-like cell winter quarters, and that tobacco dust combined with lime and sodium carbonate can, at that time, be used for its destruction.

In the spring of 1926, after the larvae had emerged from their over-wintering cells and begun the tunnelling process, a comparative test of tobacco dust and nicotine sulfate was instituted. This experiment was set May 6 and 7. Three rows of red raspberry plants on the farm of Harvey Seely, at Hammonton, were selected. Each row was about 305 feet long and the bushes looked vigorous. They had been set about three years. These rows were divided into eight blocks.

Block 1 consisted of 5 hills, each surrounded by an iron ring 14 inches in diameter. In this ring the tobacco dust dosage was sifted evenly over the enclosed area. Three and five-tenths pounds of a tobacco dust mixture were used in each of these five rings. It consisted of 50 per cent tobacco dust (0.25 per cent actual nicotine content), 49 per cent hydrated lime, and 1 per cent sodium carbonate. A thin coating of soil was thrown over the tobacco dust mixture and 1 gallon of water was poured into the ring. The tobacco dust used was about 100-mesh.

Block 2 consisted of 10 hills arranged and treated as in no. 1, except that 1.75 pounds of tobacco dust mixture was used. This mixture consisted of 50 per cent tobacco dust (0.15 per cent actual nicotine content), 49 per cent hydrated lime and 1 per cent sodium carbonate. The tobacco dust used here was about 40-mesh.

Block 3 consisted of 10 hills arranged as above and treated with 1.75 pounds of tobacco dust mixture. This mixture consisted of 50 per cent tobacco dust (0.5 per cent actual nicotine content), 49 per cent hydrated lime and 1 per cent sodium carbonate. The tobacco dust in this case was about 20-mesh.

Block 4 consisted of 10 hills surrounded by the same type of ring and treated with 1 gallon of mixture composed of 50 gallons of water, 5 pounds of hydrated lime and 1 pint of nicotine sulfate (40 per cent actual nicotine).

Block 5 consisted of 9 hills arranged as in block 4 and treated with 1 gallon of a mixture composed of 50 gallons of water, 5 pounds of hydrated lime and ¼ pint of nicotine sulfate (40 per cent actual nicotine content).

Block 6 was ridged on either side with soil and treated with a mixture consisting of 50 gallons of water, 5 pounds of hydrated lime and 1 pint of nicotine sulfate at the rate of a little less than 1 gallon to the linear foot. As soon as the water had soaked in, dry soil was hoed over the treatment.

Block 7 was ridged and treated as block 6 with a mixture consisting of 100 gallons of water, 5 pounds of hydrated lime and 1 pint of nicotine sulfate at the rate of a little less than 1 gallon to the linear foot.

Block 8 received the same treatment with a mixture composed of 200 gallons of water, 5 pounds of hydrated lime and 1 pint of nicotine sulfate.

Data were taken on the results on May 14, and are set forth in table 1.

TABLE 1

Raspberry Crown Borer Control, 1926

Block No.	Nature of Treatment	Actual Nicotine per Hill	Number of Larvae		Percentage of Larvae Killed	Hills Examined
			Alive	Dead		
		pounds				
1	100-mesh tobacco dust mixture	0.00875	2	6	75.0	3
2	40-mesh tobacco dust mixture	0.00875	5	2	28.5	4
3	20-mesh tobacco dust mixture	0.00875	4	4	50.0	3
4	1 part nicotine sulfate to 50 of water..	0.01000	3	7	70.0	5
5	1 part nicotine sulfate to 200 of water..	0.00250	3	1	25.0	3
6	1 part nicotine sulfate to 50 of water..	0.01000	6	4	40.0	6
7	1 part nicotine sulfate to 100 of water..	0.00500	8	2	20.0	5
8	1 part nicotine sulfate to 200 of water..	0.00250	14	0	0.0	6

The data serve to indicate distinctly that nicotine in the form of tobacco dust is far more efficient than nicotine in the form of "Black Leaf 40," and that the ring contributes to an increase in efficiency.[1]

Cranberry Investigations

The principal phases of work handled at the Cranberry Substation located at Whitesbog, Browns Mills, N. J., are carried on by Charles S. Beckwith, cranberry specialist; Byrley F. Driggers, assistant cranberry specialist; Carl D. Jones, biochemist in cranberry investigations, and are set forth in the report of the Cranberry Sub-Station.

REPORT OF THE CRANBERRY SUBSTATION

CHARLES S. BECKWITH, BYRLEY F. DRIGGERS,
AND CARL D. JONES

The work at the cranberry substation continued all of the old studies and started a new investigation of the nature of cranberry bog peats. Mr. Carl D. Jones is working on this problem and his part of the report is included in this paper.

Plant-Food Studies

The active plant-food studies in progress now are "The comparison of different sources of nitrogen for Savannah cranberry lands" and "A study of the effect of complete fertilizer on Savannah cranberry land."

The first is limited to a study of the effect of nitrate of soda as compared with dried blood, and also as compared with a mixture of the two. It has been in progress since 1919. The details for 1925 are given in table 1.

TABLE 1

Results of the Nitrogen Experiments on Savannah Soil

Plot	Treatment per Acre	Yield per Acre	Gain
		pounds	*per cent*
1	Nothing	1610	
2	140 lbs. Nitrate of Soda	2560	69
3	Nothing	1420	
4	70 lbs. Nitrate of Soda and 85 lbs. Dried Blood	2100	35
5	Nothing	1270	
6	170 lbs. Dried Blood	2740	86
7	Nothing	1670	
8	210 lbs. Nitrate of Soda	1760	3
9	Nothing	1730	
10	105 lbs. Nitrate of Soda and 127½ lbs. Dried Blood	2720	72
11	Nothing	1450	
12	255 lbs. Dried Blood	3890	134
13	Nothing	1870	

---

[1] A detailed account of the results of the experiments previous to last spring is given in the Journal of Economic Entomology, vol. 19, no. 3, June, 1926, pp. 471-477.

It will be noted that the plots receiving dried blood had a larger crop this year than those receiving nitrate of soda. This is the first year since this series has been in operation that this has happened and possibly it is not entirely the direct effect of the plant-foods applied although, of course, it is natural to assume that it is. If it is, the result in 1926 will bring it out more clearly and that will be time enough to draw conclusions. The fact that nitrogenous fertilizers increased cranberry crops on Savannah land has been shown before, but these plots this year give further evidence.

The second plant-food study had for its object the determination of the optimum size of application of a previously planned complete cranberry fertilizer. The mixture was made up as follows:

125 pounds	Nitrate of soda
300 pounds	Rock phosphate
50 pounds	Sulfate of potash

The first year the material was used, 300 pounds of acid phosphate was added in order to have phosphate available the year of application. The test was started in 1919 and continued to the present. The results for 1925 are given in table 2.

TABLE 2

Results of Complete Fertilizer Experiments on Savannah Land

Plot	Treatment per Acre	Yield per Acre	Gain
		pounds	*per cent*
1	Nothing	1870	
2	264 lbs. Mixture	3100	53
3	Nothing	2180	
4	528 lbs. Mixture	3530	63
5	Nothing	2140	
6	792 lbs. Mixture	3670	65
7	Nothing	2310	
8	1056 lbs. Mixture	2400	14
9	Nothing	1890	

A study of this table together with the results of previous years shows that the plot receiving 528 pounds of the mixture is gaining on the other plots in the comparative yields. Up until last year, the plot receiving 792 pounds of the mixture was undoubtedly the best, and it is now, but the margin between the two is becoming very small. As a result of the first tests the station has decided to recommend not over 500 pounds of this mixture for annual treatments.

Arsenical Weed-killers

Arsenical weed-killers are becoming more popular with growers every year and the station has been trying out a few of the newer practices. The original use of the material was to pour some of it on the base of a plant to be killed. This has replaced hand weeding on at least one bog because it kills the weed and there is no chance for live roots to break off and continue the weed growth. It has been a very satisfactory method where it was well understood.

In addition, it has been used to kill all the vegetation within a given area. For this purpose, a rather strong solution (Herbicide 1 to 40) is applied with a sprinkling pot thoroughly enough to wet all of the green parts. In order to kill cranberry vines, it is best applied just after bloom and again a month later when all parts of the area missed the first time should be treated. This method is used when it is desired to kill a mixture of weeds and cranberry vines or where it is desired to kill a patch of wild cranberries growing in a bog of improved varieties. When the land is to be replanted, it should be sanded or else the top turf should be removed for best results with the new cuttings.

In much the same way, ditches are cleared of foreign growth by weed-killer applications. The ditch should be dry when the treatment is made, but if it is necessary to have some water in the ditch the weed-killer should be made stronger so as to do the killing at about the strength of 1 to 40. It cannot be used in a ditch of running water with any effect at all.

When there is a thick growth of bracken or such weed over cranberry vines, the weed tops may be killed with a very dilute solution of weed-killer (Herbicide, 1 to 200). Although the weed roots are not killed by such treatment, the cranberry vines are entirely uninjured so they have a good chance to grow for a year. If the treatment is repeated two or three years, possibly the vines will overcome the weed growth. It has been done with wild sweet potato and at present we are trying it on bracken.

Sanding

Our sanding experiments have just been started; therefore, we will have no results of merit for several years.

False Blossom

False Blossom has been causing some alarm through the cranberry growing regions of all of the cranberry states. Together with Dr. Stevens, of the Bureau of Plant Industry, we made a survey of this disease throughout the state. Forty-six bogs distributed all the way from Farmingdale to Port Norris were visited and the presence or absence of the disease was noted. There was one case of serious damage by this disease, two additional cases where it was bad enough to cause considerable concern, and every bog of Howes or Early Blacks had some evidence of it. We did not find it at all on Jersey vines where there were no Howes or Early Blacks on the same bog, but it was present on Jerseys when they were planted in the same bog with imported varieties. All of the evidence that we have points to the conclusion that the disease was carried in the cuttings that were used in planting the bogs. We know of no way to eliminate the disease, but a grower can do much to prevent its spread by planting only disease-free cuttings. Other people are working on this interesting problem and possibly they will find a cure.

Weather in 1925

The weather conditions during the growing season of 1925 were not good for cranberry production. A frost on May 28 did some damage, the hot, dry weather during early June was unsatisfactory, but the main cause of damage was the cloudy, wet weather during the first half of July. We know that the cranberry blossoms are pollinated by insects, such as bumblebees and honeybees, and that these insects will not work well on cloudy days or at all on rainy days. The rainfall record for several places in our district is given in table 3.

Table 3

Rainfall in the Southern Interior of New Jersey, July, 1925

Station	Day of the Month															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Indian Mills		T			.10		T		2.00			.04			.30	
Imlaystown		.06			.41		.96		.26	.41		.02			.23	.03
Lakewood		.05			.30		.22	.17	1.60							

T—Trace.

We do not have records of the per cent of possible sunshine at these various stations, but we do have it at Trenton. The record is as follows: 1st-67, 2nd-31, 3rd-79, 4th-81, 5th-79, 6th-91, 7th-48, 8th-34, 9th-88, 10th-26, 11th-100, 12th-67, 13th-89, 14th-80, 15th-33 and 16th-60.

It is obvious that the cranberry blossoms had very little clear weather during their short period of existence and therefore had little chance to set fruit. Four rains distributed over the first eight days of July were common throughout our district. Lakewood alone had no rain in the second eight days. The blossoming period is chiefly during the first ten days of July, but when the bloom is not pollinated promptly, it stays a few days longer. Lakewood, then, had some chance to set a crop, and we find that there was a fair crop in this area. We do not know how much this kind of weather prevailed at the seashore, but it did extend as far south as Toms River. The condition is very unusual, but is one of the hazards of the business.

Rot Control

The spraying and dusting experiments have been continued and somewhat enlarged. The results at Hammonton are given in table 4.

This demonstration was intended to show distinctly that spray would control rot; it does that very nicely. The dust plot was added later simply to indicate just what copper-lime dusts would do in comparison with the spray. It does show that under the conditions of this experiment, the dust is not as efficient as the spray. The

TABLE 4

Spraying Experiment at Hammonton

Treatment	Yield per Acre	Rot
	pounds	*per cent*
Sprayed 5 times	3650	7
Bordeaux soap		
Nothing	0	100
Sprayed 5 times	2950	6
Bordeaux soap		
Sprayed 5 times	2500	6
Bordeaux soap		
Nothing	0	100
Sprayed 5 times	3450	7
Bordeaux soap		
Dusted 5 times	2000	80
Copper-lime		80

same thing is brought out more forcefully in another experiment carried on by Mr. Driggers reported fully under the following title:

A Comparison of Copper-Lime Dust and Liquid Bordeaux Spray to Control Cranberry Rot

Experiments were carried on in 1923 and 1924 for the purpose of comparing copper-lime dust with liquid bordeaux for the control of the so-called "blast" and "rot" of cranberries (caused principally by *Guignardia vaccinii* Shear and *Acanthorhynchus vaccinii* Shear). In both of these seasons the amount of rot showing up on any of the plots was so small that no differences could be noted between the treated and the untreated plots.

At the beginning of the 1925 season, a bog was located on the property of Mr. Haines near Chatsworth, that, from its past history, promised to develop a heavy rot infestation. During the course of the season "blast" and "rot" appeared on the bog as was expected. The "blast" was caused by *Guignardia vaccinii* Shear and the "rot," according to Dr. C. L. Shear, of the United States Department of Agriculture, was caused principally by *Guignardia vaccinii* Shear and to a lesser extent by *Acanthorhynchus vaccinii* Shear. Both these diseases have been controlled by liquid bordeaux for a number of years.

The liquid bordeaux used in this experiment was of a 5-5-50 formula. Applications were made at the rate of 250 gallons to the acre. The different strengths of copper dust used were (1) monohydrate copper sulfate (36 per cent metallic copper) 100 per cent; (2) 75 per cent copper sulfate to 25 per cent hydrated lime and (3) 50 per cent copper sulfate and 50 per cent hydrated lime. It was thought that the copper dust with a low lime content or no lime at all would probably give negative results; however, in view of the fact that it was desirable to cut down the lime content if possible in order to lower the number of pounds of material per acre, it was decided to use the strong copper sulfate dust.

A series of plots 1/80 acre in size were laid out and treated as follows: Plot 1 was left as a check; plot 2 was dusted with 50-50 copper-lime dust; plot 3 was dusted with 75-25 copper-lime dust; plot 4 was dusted with 100-0 copper dust; plot 5 was sprayed with a 5-5-50 bordeaux; plot 6 was left as a check. Plots 7, 8, 9, 10 and 11 were treated the same as plots 2, 3, 4, 5, and 6.

One application of each of the materials was made before blooming on June 23 and five subsequent treatments after bloom on the following dates: July 11, July 27, August 3, August 11 and August 25. The treatments were made the day following a rain, the dusts being applied early in the morning before the vines were dry and the spray later in the day when the vines were dry.

The differences between the plots were recorded by weighing the berries and counting the per cent of rotten berries at harvesting. The rot was determined by counting the number of rotten berries found in 400 taken at random from each plot after harvesting. Table 5 shows the yield and per cent of rot from each plot:

TABLE 5

Effect of Spray and Dust Treatments for Cranberry Rot, 1925

No. Plot	Treatment	Yield per Acre	Rot at Harvesting
		pounds	*per cent*
1	Nothing	2384	68.0
2	Dusted 6 times with 50 per cent Copper Dust	2804	50.5
3	Dusted 6 times with 75 per cent Copper Dust	2300	57.2
4	Dusted 6 times with 100 per cent Copper Dust	1104	67.0
5	Sprayed 6 times with 5-5-50 Bordeaux.......	4960	28.2
6	Nothing	2504	71.0
7	Same as Plot 2...........................	2920	48.0
8	Same as Plot 3...........................	2064	44.2
9	Same as Plot 4...........................	1720	65.5
10	Same as Plot 5...........................	5120	22.0
11	Nothing	1384	76.7

An examination of the data in table 5 shows some interesting results. Bordeaux spray gave by far the best control. The yield was over twice that of the check plots and in addition, the per cent of rot on the sprayed plots was only about one-third that of the check plots. The results from the sprayed plots were as expected and are in keeping with the well established fact that bordeaux spray will control the rot diseases of cranberries.

The results from the dusted plots show that with the kind of dust used and under the conditions of the experiment, copper, pound for pound, is not as effective in the dust form as in the liquid. The 50-50 copper-lime dust gave better yields than the more concentrated dust, indicating that there was a deficiency of lime in the 100 per cent and 75 per cent copper dusts. The 100 per cent copper dust gave a smaller yield than the check plots, which indicates that the strong copper dust had a toxic effect on the cranberry plant. It is planned to continue the experiment another year, using copper-lime dusts with a greater proportion of lime.

The Effect of the Water-Table on the Growth and Yield of Cranberries

The water-table experiment was continued during 1925 as in the previous season. On one-half of the plots the water was held at different depths below the surface (at the surface, 3 inches, 6 inches, 9 inches, 12 inches, and 15 inches) throughout the growing season and the yield, annual growth and per cent of rot recorded. On the other half of plots the water was held high until the vines were in bloom and then lowered for the remainder of the growing season.

The results for the past season follow rather closely the results obtained in 1924. Table 6 shows the data obtained where the water was held at the different levels throughout the growing season. Table 7 shows the data obtained from that part of the experiment where the water was held high until the vines were in bloom and then lowered for the remainder of the season.

TABLE 6

Annual Growth, Yield and Per Cent of Rot on Plots Where the Different Water Levels Were Held Throughout the Growing Season, 1925

	Group 1	Group 2	Group 3	Group 4	Group 5
Depth of Water Levels (inches)	0–3	3–6	6–9	9–12	12–15
Average Length of Annual Growth (inches)	2.37	2.49	2.77	2.90	3.16
Average Number of Uprights to the square foot	370	427	471	475	452
Yield (pounds)	16.7	20.5	19.2	25.6	24.3
Rot (per cent)	4.16	2.93	4.16	2.8	2.6

TABLE 7

Annual Growth, Yield and Per Cent of Rot on Plots Where the Water Was Held High Until Blossoming and Then Lowered for the Remainder of the Season, 1925

	Group 1	Group 2	Group 3	Group 4
Depth of Water Level (inches)*	0–4; 7–9	4–7; 9–11	7–9; 11–13	9–11; 13–15
Average Length of Annual Growth (inches)	2.46	2.66	2.88	2.85
Average Number of Uprights to the square foot	397	403.3	423	411
Yield (pounds)	9.9	18.6	17.1	20.7
Rot (per cent)	1.33	2.7	2.1	2.7

*First two figures show depth of water up to blooming; second two figures show depth of water from the blooming period to the end of the growing season.

The data in table 6 show a direct correlation between depth of water below the surface of the bog and the vegetative growth as expressed by the average length of the annual growth and the average number of urights to a square foot. Table 6 also shows a similar correlation between the depth of the water level and the yield. There was comparatively little rot on any of the plots represented in table 6 and 7 for this season. The per cent of rot for this season does not follow that of the two previous seasons, when the highest percentage of rot was found where the water levels were held high. Three factors can be cited that may explain the small amount of rot on the experiment as a whole during the past season. At the beginning of the season about one-half of the probable crop was destroyed by frost. A week of hot dry weather just before bloom further reduced the crop by causing a part of the flower buds to become blasted. The remaining light crop on the vines encountered good weather, as regards rot infection, for the remainder of the season. Another factor that may be taken into consideration is the fact that the berries were picked about ten days before maturity, consequently the rot had less time to show up in infected berries.

The data in table 7 show results that are somewhat indefinite. An effort was made after blooming to lower the water under groups 1 and 2 to a point equal to the depth of groups 3 and 4. However, seepage from higher to lower levels and lack of depth in some of the ditches caused the water to stand at a higher level under group 1 and to slope off toward group 4. As a result, the data in table 7 follow somewhat the trend of the data in table 6.

The Effect of Cranberry Bog Flowage Water on the Larvae of the Japanese Beetle, *Papillia japonica* Newm.

The advent of the Japanese beetle into the cranberry region during recent years has led to the question of the ability of the insect to withstand flowage conditions on cranberry bogs. The stage of the insect that would be affected by flowage is the larva. Other beetle larvae (such as the larvae of the Cranberry Root Worm *Rhabdopterus picipes* Oliv, and certain White Grubs) are able to withstand spring and fall, and even winter flowage, according to Scammell.[2] Therefore it was thought that the Japanese beetle grubs would also survive short periods of flowage and possibly the long winter flowage. The following experiments were carried out in an effort to clear up these points.

On May 8, 1925, several hundred larvae were secured from near the Japanese beetle laboratory at Riverton, N. J., and treated as follows: In a glass vessel, 100 of the larvae were submerged to a depth of 10 inches in bog water. Four hundred of the remaining larvae were divided into lots of 20 each and each lot placed near the center of a quart can of bog soil. The tops of the cans were covered with cheese-cloth and holes punched in the bottoms and sides. The 20 cans of soil containing the larvae were placed in an open crate and sunk to a

---

[1] Particularly *Phytalus georgianus* Horn, *Dyscienetus trachypygus* Burm. and *Lachnosterna grandes* Sm.

[2] Scammell, H. B. 1917 Cranberry insect problems and suggestions for solving them. U. S. Dept. Agr. Farmers Bul. 860.

depth of 10 inches in one of the ditches on the bog. One can was left out of the water to serve as a check.

From day to day one of the cans was removed from the water and the live and dead larvae recorded. At the same time five of the larvae in the bog water were removed and the live and dead larvae recorded.

Table 8 shows the number of live and dead larvae found in the water and soil from day to day.

TABLE 8

Effect of Bog Water on Japanese Beetle Larvae Exposed and Embedded in Bog Soil

Date Examined	Larvae in Bog Water		Larvae in Bog Soil Covered with Water		Larvae in Bog Soil (Check)	
	Dead	Alive	Dead	Alive	Dead	Alive
May 9	3	2	2	18	..	..
10	1	4	1	19	..	..
11	0	5	0	20	..	..
12	3	2	4	16	..	..
13	2	3	4	16	..	..
14	3	2	5	15	..	..
15	3	2	6	14	..	..
16	2	3	3	17	..	..
17	3	2	4	16	..	..
18	4*	1	5	15	..	..
19	4	1	10	10	..	..
20	3	2	9	11	..	..
21	1	4	7	13	..	..
22	3	2	10	10	..	..
25	4	1	12	8	..	..
28	4	1	15	3	..	..
June 1	25	0	11	9	..	..
4	..	..	17	3	3	17

*From ten days on, many of the larvae in the water were affected by a fungous growth which formed a quite distinct halo of fungous bodies about the grub.

The data in table 9 indicate that the grubs of the Japanese beetle are able to survive submerged in bog water for a period of 10 days to two weeks during the month of May. During the latter part of May and the first of June, cranberry bogs are usually flowed to control certain insects. This flowage rarely extends over a period of 48 hours. Therefore, the indications are that the Japanese beetle grubs would not be materially affected by the spring reflow.

An additional experiment was carried on during the fall, winter and spring of 1925-26 to determine whether or not the grubs could become established in cranberry bogs and successfully pass the winter under flowed conditions.

On September 28, 1925, a number of Japanese beetle grubs were secured from the Japanese beetle laboratory at Riverton. One hundred and fifteen grubs were placed in each of two wire cages 1 by 1 by 2 feet, filled with peat and sand mixed half and half. One of the cages was placed in a cranberry bog so that the top of the cage was about 3 or 4 inches below the surface of the bog. The other cage, which was to serve as a check, was buried at the same depth on high ground near the insectary. The winter flowage was placed on the bog December 10, 1925, and remained at a depth of 2 to 3 feet until April 18, 1926, when the water was drawn off. On May 14, the two cages were opened and the soil carefully examined for live and dead larvae. Table 9 shows the condition of the larvae in the submerged and check cages on May 14, 1926.

Table 9

The Effect of Winter Submergence on the Japanese Beetle Larvae Where the Water Was Held Four Months

	Larvae in Cage	Larvae Alive	Larvae Dead	Larvae Missing
Cage under water	115	0	67	48
Cage out of water......	115	38	11	66

The data in table 9 indicate that the grubs of the Japanese beetle are not able to go over the winter under bogs that are flowed for a period of four months during the winter and spring.

Insects of the Cultivated Blueberry

During the past season, the junior writer, B. F. Driggers, has been carrying on life-history studies on the different insects found on the cultivated blueberry. Few of these have become of economic importance as yet. However, as the blueberry plantings are becoming more extensive from year to year, it is to be expected that the insects native to the blueberry, and also some of the cranberry insects, will increase. Among the insects that have received attention during the past season are: (1) A gall fly that damages the growing tips; (2) a stem borer resembling the raspberry stem borer; (3) a Lepidopterous larva that bores in the berries; (4) several Hymenopterous parasites associated with a gall on the stems and (5) the cranberry root worm.

The first of these, the blueberry tip worm *Contarinia vaccinii* Felt, was described in a recent paper.[1] Dr. E. P. Felt, of the New York State Agricultural Experiment Station, furnished the description of the adult, which proved to be a new species. Descriptions of the egg, larva and pupa and the injury to the plant were supplied by the writer.

Experiments are now under way looking toward the control of the cranberry root worm on blueberry. Two of the more promising insecticides, calcium cyanide and sodium fluosilicate, are being tried out against the adult of this insect. The experiments so far indicate that it can be controlled by fumigating with calcium cyanide shortly after the beetles emerge from the soil and begin egg laying and feeding.

---

[1] In the Journal of the New York Entomological Society (Vol. 34, March, 1926).

The Nature of Cranberry Bog Peat

In July, 1925, a study of the nature of cranberry bog peats was begun by C. D. Jones. Previous observations made upon certain of the older cranberry bogs had indicated that they were developing a state of lowered productivity, a tendency which it was desired to remedy, but concerning the nature of which little was known. Work on such a problem necessitated a more extensive and more definite knowledge of the biochemical processes taking place in such soils and accordingly a general survey of the microbiological and chemical factors involved was undertaken.

The acidity of the peat in cranberry bogs is extremely marked. Potentiometric determinations gave pH values ranging downward to as low as 3.02 in small localized areas. The general range in reaction is well illustrated by the data in table 10.

TABLE 10

Reaction of Bog Peats

Site of Bog	Depth of Sample	pH
	inches	
60-year-old bog	0-1	3.71
Water-table plot No. 22	0-1	3.61
Water-table plot No. 22	10-12	3.35
North Branch, new bog, black peat	0-1	3.83
North Branch, new bog, brown peat	0-1	3.65
Fertilized plot No. 6	0-1	4.41
Check plot for above	0-1	3.82
Limed plot 3,000 lbs. annually for 3 years	0-1	7.12
Check plot for above	0-1	3.99

This degree of acidity together with the moist and poorly aerated conditions usually found in such peats keeps down the microorganic population to very low numbers. Plate counts made after the usual methods gave fungi in numbers ranging from 20,000 to 200,000 per gram of peat, the more common counts being 40,000 to 60,000. Bacterial numbers varied from 20,000 to 100,000 with only an occasional higher count being observed. Anaerobic numbers were not determined. Significant numbers of actinomycetes were found only in limed areas, the influence of the peat's reaction being shown by the following:

Limed plot	pH 7.12	800,000 actinomycetes per gram
Unlimed check	pH 3.99	no actinomycetes per gram

Protoza were few, not over 200 to 300 per gram of peat being found.

Such a low microbiological population in material comprised 80 per cent or more of organic matter indicates a rather inactive state of decomposition. The existence of such great accumulations of partly decomposed plant residues is fairly ample proof that either this residual material is itself extremely resistant to further decomposition, or that environmental conditions encountered in the bog effectually prevent attack by the usual organisms, or that both the above causes are contributing factors. On the assumption that a more active decomposition of the peat would prove beneficial to the economic crop, due to increased availability of mineral plant-food elements in the accumulated residual material, experiments were designed to study the influence of moisture content, aeration and acidity, and to ascertain the effect of added organic and inorganic substances.

In these experiments the rate of decomposition was measured by the amount of CO_2 evolved per unit interval of time. The peat used was freshly dug material obtained near one of the check plots of the water-table series. While still moist it was sieved and weighed into the flasks of the aeration apparatus. In table 11 the weight of the peat sample, the treatment, duration of the experiment, and the total amount of carbon in the carbon dioxide evolved are given.

TABLE 11

Influence of Water Content Upon Rate of Decomposition of Cranberry Bog Peat

Water in 100 gm. of material.	C in the CO_2 evolved in 30 days.
gm.	*mgm.*
45.0	72.9
47.0	73.0
51.7	73.0
56.7	60.4
61.3	71.2
66.2 (nearly saturated)	57.5
70.2 (saturated)	58.7

In succeeding experiments the peat used contained approximately 50 per cent of dry matter. Care was also taken to keep the peat of uniform depth in the flasks so as to avoid variations due to irregular settling or packing of the material.

TABLE 12

Influence of Fertilizer Upon CO_2 Evolution

Treatment	C in CO_2 evolved in 30 days
	mgm.
100 gm. peat (check)	59.7
100 gm., 2 gm. $CaCO_3$	260.3
100 gm., 0.1 gm. dried blood	80.8
100 gm., 0.1 gm. $NaNO_3$	56.3
100 gm., 0.1 gm. urea	70.4
100 gm., 0.1 gm. acid phosphate	54.4
100 gm., 1.0 gm. dried blood	278.6

TABLE 13

Decomposition of Peat Organic Matter When Mixed With Large Amounts of Inert Material

Treatment	C in CO_2 evolved in 28 days
	mgm.
100 gm. sand	17.2
100 gm. sand, 1 gm. peat	20.8
100 gm. sand, 1 gm. peat	22.7
100 gm. sand, 25 gm. peat	35.7
100 gm. sand, 1 gm. peat, 0.5 $CaCO_3$	25.5
100 gm. sand, 5 gm. peat, 0.5 $CaCO_3$	46.8
100 gm. sand, 5 gm. peat 2.5 $CaCO_3$	59.2
100 gm. sand, 1 gm. peat, 0.1 ammonium phosphate	18.4
100 gm. sand, 5 gm. peat, 0.5 ammonium phosphate	23.6

TABLE 14

Effect of Added Organic Matter Upon the Evolution of CO_2 From Peat

Treatment	C in CO_2 evolved in 49 days
	mgm.
80 gm. peat	49.3
80 gm. peat, 2 per cent cellulose	54.1
80 gm. peat, 2 per cent straw	69.3
80 gm. peat, 2 per cent soybean meal	84.4
80 gm. peat, 2 per cent cellulose, 1 per cent $CaCO_3$	99.5
80 gm. peat, 2 per cent straw, 1 per cent $CaCO_3$	118.6

TABLE 15

Effect of Different Forms of Nitrogen Upon the Evolution of CO_2 From Peat

Treatment	C in CO_2 evolved in 28 days
	mgm.
40 gm. peat	54.7
Nitrogen applied at rate of 0.104 gm. per flask as:	
Urea	101.2
Ammonium sulfate	54.9
Sodium nitrate	66.4
Ammonium nitrate	67.7

The above results indicate that the peat does not readily respond to the above treatments. Table 14 brings out that the material itself does not break down readily even when mixed with large amounts of sand so as to form a well aerated compost. The effects of various mineral fertilizer compounds are not very marked. The results secured from application of different forms of nitrogen indicate that this element is not the limiting factor for microbiological activities in the peat even though the carbon-nitrogen ratio of this material is about 20:1, a rather wide ratio as compared to the approximate 10:1

equilibrium maintained by microorganic activities in the humus of ordinary soil.

Other work is now in progress dealing with the long time effects of lime upon fairly dry, well aerated peat. Certain composts of this nature have indicated that such treatments can markedly alter the appearance and physical texture of the peat while at the same time the microflora both changes its character and increases in density.

The range in acidity, or local variations in reaction, of different peat bogs, also is being studied. Where possible, such variation is to be correlated with the appearance of the cranberry plants growing on such areas. In connection with this, the reaction limits tolerated by growing cranberry plants will be investigated by means of field plots and pot cultures in which the acidity is artificially controlled.

Soil Infesting Insect Investigations

Wire-worms

In the annual report for the year ending June 30, 1925, it was stated that experiments on wire-worms with such materials as "Calma," "Fluosilicate," "Limag" and "Naphthalene" were going forward. These were preliminary experiments to indicate whether any of these substances had possibilities, from the standpoint of practical control of wire-worms. When "Calma" and soil were mixed at the rate of 1 to 100, and the resultant mixture placed in tin salve boxes into each of which a wire-worm was introduced, it was found that the wire-worms were unhurt for a period of 30 days. This experiment began on August 24 and was discontinued on September 23. Greater dilutions of "Calma" were tried, but, of course, no kill was obtained.

A similar mixture of calcium fluosilicate with soil was tried, under similar conditions, and from November 11 to 21, a period of 10 days, the wire-worms were unaffected. As in the preceding experiment, greater dilutions were used, but no results were obtained. A similar experiment with "Limag" and soil was tried, beginning August 24 and ending September 23, a period of 30 days. Throughout this period the wire-worms were alive and vigorous. Again, as in the previous experiments, greater dilutions were tried, without any killing.

"Naphthalene," on the other hand, showed much more vigor. On August 24 a mixture of soil and naphthalene at the rate of 1 to 1000 was made and placed in tin salve boxes into each of which a wire-worm was introduced. On August 29, the wire-worms were dead. Of the four substances mentioned "Naphthalene" is the only one which showed any promise and this lead will be followed further.

Of course, checks were run throughout in which a single worm was placed in a tin salve box with an amount of soil equal to the total amount used in each of the boxes containing mixtures and the wire-worms lived actively for a period of 30 days, when the experiment was discontinued.

In the report for the year ending June 30, 1925, it was shown that either carbon bisulfide or calcium cyanide applied to the soil with a temperature of 60° to 70°, at a time that the plants were not present, would destroy a very high percentage of the wire-worms. The calcium cyanide being in lethal dosage considerably cheaper than the carbon bisulfide, a further experiment was begun in the spring of 1926. This experiment was set at the farm of Henniger and Bender, and at the farm of Mr. John Bender in the Richfield district near Paterson. The application was made with a special machine attached to the plow beam and the material distributed in the open furrow, which was promptly filled by the turning furrow slice. The applications were made on May 19, 1926, and on June 1 Mr. Harold Wettyen, county agricultural agent, examined the plots at John Bender's place. Mr. Wettyen dug an aggregate area of 18 square feet, consisting of a number of well distributed component plots. He dug to the subsoil in each case and found in these 18 square feet 80 wire-worms of which eleven were alive and 69 dead, indicating a kill of 86 per cent. On the same date Mr. Wettyen examined the treated plots at Mr. William Englebrecht's place, which were treated in the summer of 1925. He reported an excellent crop of spinach and cabbage on these plots with practically no plants missing.

Bee Investigations

RAY HUTSON

Introduction

The honeybee investigations for the year have consisted of a continuance of work on the problems previously mentioned; the determination of the relation of the honeybee to fruit growing; and the breeding of European-foulbrood-resistant and high-producing strains of honeybees. In additions, tests have been made on the killing power of a mixture of ethyl acetate and carbon tetrachloride against waxmoth, and further tests on the use of chlorine gas as a disinfectant for use in the treatment of honeycombs infected with American foulbrood.

Pollination Studies

The investigations[1] made in other parts of the United States, as well as in New Jersey, show the honeybee as an effective agent in the pollination of fruits. As intimated in the introduction, the work on this problem is a continuation of the studies hitherto made.

---

[1] Tufts, W. P. 1919. Pollination of the Bartlett pear. Cal. Agr. Exp. Sta. Bul. 307.

Hendrickson, A. H. 1919. Plum pollination. Cal. Agr. Exp. Sta. Bul. 310.

Waite, Merton B. 1895. Pollination of pear flowers. U. S. Dept. Agr. Div. of Veg. Path. Bul. 5.

Lewis, C. I., and Vincent, C. C. 1909. Pollination of the apple. Ore. Agr. Exp. Sta. Bul. 104.

Morris, O. M. 1921. Studies in apple pollination. Wash Agr. Exp. Sta. Bul. 163.

Hutson, Ray 1923-1925. Report of the Department of Entomology. In N. J. Agr. Exp. Sta. 44th, 45th, and 46th Ann. Rpt.

TABLE 1

Bees on Starr Trees, Minch Brothers Orchard

Tree No.	May 6	May 8
1	1	3
2	3	4
3	3	1
4	7	2
5*	13	4
6	4	0
7	7	3
8	8	4
9	4	3
10	0	0
11	6	1
12	3	2
13	0	0
14	6	5
15	10	4
16	4	3
17*	2	2
18	5	2
19	0	0
20	4	1
21	11	5
22	7	4
23	6	5
24	2	2
25	0	0
26	5	2
27	6	2
28	0	0
29	3	2
30*	0	0
31	8	5
32	8	1
33	3	7
34	0	0
35	1	0
36	3	9
37	1	1
38	3	4
39	6	4
40*	5	2
41	4	3
42	4	2
43	6	3
44	3	2
45	9	2
46	3	2
47	3	2
48	2	3
49	4	2
50*	2	4
51	2	2
52	2	2
53	2	3
54	3	1
55	4	1
56	4	1
57	5	1
58	3	1
59*	2	1

Confirmation observations on distribution of honeybees, varietal preferences, and prevalence of insects other than honeybees have been sought.

Distribution of Honeybees About Groups of Hives

Hives were placed in Minch Brothers Starr planting at Linden orchard, approximately 210 feet apart each way, and for comparison a group of 5 hives were placed in their Williams Early Red planting at Mortar Brick orchard. Count of bees on trees were made at both places on two different days as nearly together as the trip of 2 miles by auto could be safely made. The plan of counting was that of observing the number of bees on every tree in the row containing bees.

TABLE 2

Bees on Williams Early Red Trees, Minch Brothers Orchard

Tree No.	May 6	May 8
1*	4	5
2	1	4
3	2	3
4	3	1
5	0	3
6	3	3
7	2	0
8	2	5
9	0	0
10	0	1
11	1	1
12	0	2
13	1	0
14	1	0
15	1	3
16	2	2
17	0	0
18	0	2
19	0	2
20	0	2
21	0	1
22	1	1
23	1	1
24	1	1
25	1	3
26	3	2
27	1	3
28	0	0
29	0	1
30	1	3
31	0	2
32	1	0
33	1	2
34	1	0
35	2	1
36	1	1
37	2	0
38	1	2
39	0	1
40	1	0
41	2	2

The object of the counts was to ascertain the accuracy of the previously reported observation that bees tend to concentrate about groups of hives. The numbers of bees on trees placed in the two ways are shown in tables 1 and 2. The location of the hives in the plantings is indicated by asterisks opposite the tree numbers in the tables.

A further light is thrown upon the effect of hive placing by the counts of set made on trees in the two orchards. In the Starr planting, trees were selected at the hive site (No. 1), 40, 80, and 120 feet away. In the Williams planting trees were selected at the hives (No. 1), 40, 80, 120 and 240 feet away. The fallen pedicels under the selected trees were collected and counted, and also the fruits on the trees were counted. From these figures the percentage of set was computed and given as in table 3.

TABLE 3

Results of Blossom and Apple Set Counts in Minch Brothers Orchards

Distance from hives	Tree	Blossoms	Fruit Set	
			Number	Per Cent
At hives	Starr Williams	1830 1910	965 539	53.0 28.1
40	Starr Williams	1399 1180	289 177	20.0 15.0
80	Starr Williams	2387 1818	341 200	14.2 11.0
120	Starr Williams	1714 3531	536 219	31.2 6.2

The results of the study of distribution about hives may be regarded as confirming the conclusions reached in previous years on the same subject.[1] The varieties are different and of course show different percentages of set, but the same trends are evident. When hives are placed singly, approximately 210 feet apart each way, the set is as large away from the hives as in their vicinity; when groups of hives are used the set decreases as one goes away from the hives.

Varietal Preferences Exhibited by Bees

Different plants closely related show varying attraction for bees, a fact long recognized by beekeepers. Some little work on this problem as affecting pollination is included in last year's report.[1] This year further work was done. Bees were counted on 10 trees of each variety available and the results averaged. The average number of bees per tree on each variety is listed in table 4.

---

[1] N. J. Agr. Exp. Sta. 44th (1923) and 45th (1924) Ann. Rpt.

TABLE 4

Attraction of Bees by Different Varieties of Apples

Variety	Bees per tree
Jonathan	7.8
Paragon	7.3
Winesap	7.0
Grimes	5.9
Smokehouse	4.8
Stayman	3.7
Delicious	3.0
McIntosh	2.7
Gravenstein	2.6

Because of differences in the size of the trees and the amount of bloom these figures were not regarded as conclusively showing the true condition, so further tests were made with bouquets of the same size placed in tubs of water at the optimum distance, determined in the following manner. Only possible pollinators were tested. As a preliminary test bouquets of Grimes were placed in tubs, immediately in front of the hive, 5, 10, 15, and 30 feet away and the bees visiting each in one hour counted. Table 5 gives these numbers.

TABLE 5

Attraction of Bees by Grimes Blossoms

Distance from hive	Number of bees in 1 hour
feet	
At hive	1
5	4
10	8
15	17
30	1

The results listed in table 5 together with the experience of last year[1] led to the placing of the bouquets in the varietal preference test 15 feet from the hives. The number of bees visiting equal-sized bouquets of different varieties placed 15 feet from the hive is given in table 6.

TABLE 6

Attraction of Bees by Blossoms of Six Varieties of Apples

Variety	Number of bees in 1 hour
Grimes	27
Jonathan	22
Gravenstein	19
Smokehouse	18
Delicious	13
McIntosh	11

[1] N. J. Agr. Exp. Sta. 46th (1925) Ann. Rpt.

The preferences shown by bees for certain varieties are undoutedly due to some variation in the amount of nectar and pollen available. That bees do show a preference is of significance to the fruit grower and should be taken into account in planting. That the preferences are different under other conditions cannot but be true if we recall the variation in nectar secretion displayed by various plants. The facts brought out in the test to determine the best distance for pollinator bouquets from the hives is of especial weight in any orchard where such means are used to secure adequate cross fertilization. The study reported is supported by random observations in other orchards, that bees do not visit the bouquets placed near the hives so readily as when they are 10 or more feet away.

Collections

The plan of an hour's collecting daily was followed during the blooming period. Every effort was made to secure all the insects seen. The results are given in table 7.

Table 7

Daily Collections During Blooming Period

May 6	May 7	May 8
1 Megachile	1 Xylocopa	1 Megachile
1 Xylocopa	2 Halicutus	1 Halicutus
1 Halicutus	5 Bumblebees	7 Bumblebees
12 Muscids	6 Muscids	8 Muscids
8 Bumblebees	12 Chironomids	119 Chironomids
Wind (miles per hour) 13	18	30
Mean Temperature (F.) 62°	68°	68°
Humidity at noon (per ct.) 34	36	36

The collections this year serve to substantiate the conclusion reached in previous years that comparatively few insects are present at blooming time in southern New Jersey orchards. The most striking thing was the few Chironomid flies. Halictus was collected for the first time. In this connection a sod orchard at Pattenburg, Hunterdon County, was visited during its blooming period 2 weeks later when an hour's collecting gave 1523 Halictus, 32 Bumblebees, and 20 Muscids. The weather conditions on the whole were good for insects' work, although on May 8 the wind was rather high.

Ethyl Acetate-Carbon Tetrachloride Mixture for Fumigation Against Waxmoth

Tests were made of the efficiency of a mixture of ethyl acetate and carbon tetrachloride as a substitute in fumigation against waxmoth (*Galleria Mellonella* L.) The material is effective at temperatures of about 60°F.[1]

The results may be briefly summarized as follows: Larvae and pupae were exposed for given periods to varying concentrations of the vapor in bell jars of known capacity, and the kill ascertained The concentration, kill and time appear in table 8.

---

[1] The results appeared in the *American Bee Journal* for June, 1926, v. 66, p. 273-274.

TABLE 8

Kill of Waxmoth by Mixture of Ethyl Acetate and Carbon Tetrachloride

Concentration, pounds per 1000 cubic feet	Number killed in given exposure		
	24 hours	*48 hours*	*72 hours*
Larvae			
45	10	10	10
30	10	10	10
22½	9	9	10
15	2	6	6
Pupae			
45	10	10	10
30	8	10	10
22½	4	5	5
15	2	2	2

Gaseous Chlorine as a Disinfectant for American Foulbrood

As detailed in the last report, tests are being made of moist chlorine gas as a disinfectant for American foulbrood infected combs. In every case it has been impossible to culture the causative organism from treated combs. This condition has been met before by various investigators[1] and does not always mean the organism has been killed. The first combs treated are still in use after one year and have not shown disease. Other combs treated for the same length of time (48 hours) developed the disease. Tests are now going on with the use of both dry combs and combs containing honey treated 3, 4, 8, and 30 days. These were put into the hives May 29, and did not show disease on June 29. Last year combs were put in the hives in May and did not show disease until August.

Breeding Bees

The breeding of European-foulbrood-resistant and high-producing bees has been carried on during the year at the apiaries established for that purpose, and at the bee mating grounds near Chatsworth, Burlington County.

No great change has been made the past year in the technique of breeding. Briefly it is this, the queens are reared in the yard, by the Doolittle method, introduced to nuclei containing six to ten thousand worker bees and a few selected drones. An effort is made to have about 5 pounds of honey and some sealed brood in the nucleus.

After placing on the plains, feeders are put upon each nucleus and upon the 10-frame hive containing the selected drones. A drip arrangement provides for outside feeding of a 1 to 8 sugar and water solution. The general plan has been to visit the plains once a week, taking down virgin queens and bringing away queens mated during the period between the two visits.

---

[1] White, G. F., U. S. Dept. Agr. Bul. 810.

Disease-resistant Strains

During the last year, the work of testing and selecting the queens reared from the foundation stock, has proceeded in the usual manner of rearing a number of queens, mating them upon the plains, testing them in the yard for resistance of European foulbrood, and eliminating those which show the disease. Several queens whose progeny did not show the disease last summer were discarded this spring.

The following queens are considered worthy of record:

P=Parent stock

Queen C. Spicer. Queen has maintained an average of 8 frames of clean brood during past year. The bees are gentle and have produced 90 pounds of honey to July 1.

Queen T. Parentage, F_2P mated with F_1P drone. Has produced to July 1 an average of 6 frames of brood and 92 pounds of honey.

Queen J. Cutts F_2 mated to F_2P drone. Bees have lost nervousness of Cutts bees and produce honey. Show scattering cells of European foulbrood.

Queen A_2. Parentage, F_1P mated with F_1P drone. Produced a colony ready for winter. Has not shown European foulbrood. Produced to July 1 an average of 8 frames of brood at all times and 85 pounds of honey.

Queen H. Parentage, F_1P mated with F_1P drone. Produced a colony for winter. Has not shown European foulbrood. Produced to July 1 an average of 7½ frames of brood at all times and 75 pounds of honey.

Queen M. Parentage, F_1P; mated with F_1P drone. Produced a colony for winter. Has not shown European foulbrood. Produced to July 1, 7 frames of brood at all times and 70 pounds of honey.

Queen S. Parentage F_1P; mated with an F_1D imported drone. Produced a colony for winter. Has shown up to 10 per cent European foulbrood on last four examinations. Produced to July 1 an average of 8 frames of brood, and 45 pounds of honey.

Queen V. Parentage, F_1P; mated with an F_1D imported drone. Produced a colony for winter. Showed 5 per cent European foulbrood on April 9 and May 11. Produced to July 1 an average of 7 frames of brood. No surplus.

High-production Strains

The same procedure described for the New Lisbon Yard, has been followed at the production yard at Lebanon, except that honey production and not disease resistance is the deciding factor. Up to July 1 there has been no honey flow and no colony gathered a surplus. Such a condition, however, gives opportunity for observation of the laying power of queens.

Queen C. Parentage F_1F mated to F_2F drone. Compact layer. Maintained average of 4 frames of brood from August 1 to November 2, 1925. Maintained average of 8 frames from March 26 to July 1 with 13 as highest number. Produced 23 pounds of honey last fall.

Queen D. Parentage, F_1F mated to F_2F drone. Maintained average of 5 frames of brood from July 15, 1925 to October 15, 1925. Average of 6½ frames March 26 to July 1, 1926.

Queen E. Parentage, F_1F mated to F_2F drone. Maintained average of 6 frames of brood from August 1, 1925 to October 6, 1926; 38 pounds surplus. Maintained average of 8 frames of compact brood from March 26 to July 1, 1926.

Queen F. Parentage, Basswood, purchased from Root Company in 1922. Introduced August 17, 1922. Selected as breeder because of record of bees. Died in winter.

Queen Fâ. Parentage, F_2F mated to F_2F drone. Dam Queen C. Maintained average of 4 frames of compact brood from August 1 to October 6, 1926, 52 pounds of surplus honey. Has maintained an average of 8 frames of compact brood from March 26 to July 1, 1926.

Queen G. Parentage, F_2F from R mated to F_2F drone from R. Maintained average of 4 frames of brood from July 15 to October 6, 1926. 35 pound of surplus honey. Average of 7½ frames of compact brood March 26 to July 1, 1926.

Queen H. Parentage, F_2F mated at Lebanon. Produced a colony which wintered in 1925. Has kept an average of 6½ frames of brood from March 26 to July 1, 1926.

Queen I. Parentage, F_1F mated to an F_2F drone from Fâ. Maintained an average of 4 frames of brood from July 15 to October 6, 1925. Has kept an average of 8½ frames from March 26 to July 1, 1926, with a high number of 16.

Queen J. Parentage, F_1F, mated at Lebanon. Introduced July 15, 1925. Maintained an average of 6 frames of brood from April 1, 1925 to July 1, 1926.

Queen K. Parentage, F_1F mated to F_2F drone. Introduced August 19, 1925. Maintained average of 5 frames of brood from April 1 to July 1, 1926.

Queen L. Parentage, F_1F mated to F_2F drone from A. Introduced August 19, 1926. Maintained April 1 to July 1, 1926, 6 frames of brood.

Queen M. Parentage, F_1F mated F_2F drone from A. Introduced August 19, 1926. Average of 5½ frames of brood April 1 to July 1, 1926.

Queen N. Parentage, F_1F mated to Italian drone at Lebanon. Started laying August 11, 1926. Maintained 4 frames of brood until October 6, 1926. Maintained average of 7 frames April 1 to July 1, 1926.

Queen O. Parentage, F_1F mated to an Italian drone at Lebanon. Started laying August 11, 1926. Maintained 4 frames of brood until October 6, 1926. Kept an average of 6 frames of brood from April 1 to July 1, 1926.

Queen P. Parentage, F_1F mated to Italian drone at Lebanon. Started laying August 11, 1926. Kept 4 frames of brood until October 6, 1926. From April 1 to July 1, 1926, maintained 6 frames of brood.

Queen Q. Parentage, Root F_1F mated to an Italian drone at Lebanon. Started laying August 11, 1926. Average of 3 frames of brood until October 6. From April 11 to July 1, 1926, maintained an average of 5 frames of brood.

Queen R. Parentage, F_1F mated to an Italian drone at Lebanon. Started laying August 28, 1926. Maintained an average of 4 frames of brood until October 6. From April 1, to July 1, 1926, maintained an average of 6 frames of brood.

Mosquito Control Investigations

This project is made the subject of a special section at the end of this report and need not be discussed at this point.

Mosquito Control

THOMAS J. HEADLEE AND FRANK W. MILLER

Investigations

Disappearance of Oil from Polluted Water

Impounded or partially impounded sewage polluted waters are generally a source of prolific mosquito breeding. In most instances the only practical control is the application of oil or, in a few cases, larvicide. Oil has proved unsatisfactory in many instances since the film, so necessary for exterminating the mosquito in the larval stage, as a rule quickly becomes ineffective.

The purpose of this investigation was to ascertain the responsible agency. Sewage polluted water was taken from the Passaic River, above the Dundee dam for a practical demonstration.

First, a sample of the polluted water secured from the above location was placed in a beaker; at the same time another beaker was filled with distilled water. An oil film was next spread over the surface of each and a watch maintained for durability. In about two and a half days oil had entirely disappeared from the surface of the polluted water, whereas traces of oil were noted twelve days later on the distilled water surface.

Following this a series of tests was conducted by Dr. Rudolfs on the influence of certain bacterial cultures and their end products, upon the persistence of the oil film.

No.	Material	Length of run	Oil
1	Hydrogen sulfide producers	5 days	some reduction
2	Hydrocarbon digesters	30 hours	disappeared
3	Mixed culture of 1 and 2	36 hours	disappeared
4	Hydrogen sulfide gas	3 hours	disappeared
5	Methane gas	16 hours	present
6	Carbon dioxide gas	18 hours	present
7	Sewage gas	3 hours	some reduction
8	Sewage gas (lab)	20 days	present
9	Distilled water (several)	20 days	present

It seems, therefore, that hydrocarbon-digesting organisms are probably directly responsible for the breaking up of the oil film, while bacteria attacking protein materials, releasing H_2S, seem to have effect through the production of this gas.

Mosquito Repellents

A study of mosquito repellents carried on during the past four years by Dr. Rudolfs was terminated during the summer season of 1925. A large number of the essential oils, single constituents of these oils, which give them their odor or apparent toxic qualities, and other substances, which would afford protection against adult mosquitoes, were tried. The reaction of mosquitoes to the various substances was determined both in the laboratory and in the field. In summarizing the results, it was found that thujo oil, cinnamic aldehyde, anisic aldehyde, bergamot oil, clove oil, and pyrethrum extract (ordinary insect powder extract), were most effective. When mixed with vaseline, cold cream, or face powders, they gave considerably longer protection than when applied alone. In making such a repellent it was found that about 4 to 6 parts of oil or extract mixed with 94 to 96 parts of vaseline or cold cream was most satisfactory. Should a repellent in powder form be more desirable, the oil or extract can be mixed with wheat flour, face powder, or talcum powder. In this case oil is used only in such quantities as the powder will absorb without forming a paste. Protection seems to be based primarily on the volatility of the oils or active substances in the materials. When the oil is mixed with vaseline, volatilization is retarded and the user secures longer protection from mosquito bites. When the oils are used alone, protection rarely exceeds from one to one and one-half hours as compared with from two to three hours when used with jelly or powder.

These experiments were carried out under trying conditions, mosquitoes alighting on unprotected persons at an average of from five to twenty a minute.

Studies on Food for Mosquito Larvae

The studies on food for mosquito larvae were continued by Dr. Rudolfs during the past year. The data in hand are quite voluminous and the general conclusion only is presented here. Sample water areas, some of which bred continuously throughout the summer months, and others, where breeding would supposedly not take place, were selected. Water in these areas was collected and analyzed, chemically, and microscopic determinations were made of the life contained therein. The results showed that the chemical composition of the water determines the food supply, provided sufficient sunlight is present.

Mosquito Migrations

One of the most important biological problems facing successful mosquito work is the knowledge of mosquito migrations. It was early discovered that certain species had a considerable migratory range, while others were practically local in character. That migrating adults of various species have complicated and nullified otherwise successful campaigns in the past in limited areas, has frequently been demonstrated.

Flights of the mosquitoes common in New Jersey have been carefully studied both by the late Dr. John B. Smith and by Dr. Thomas J. Headlee. Data have been obtained showing that certain species of salt marsh mosquitoes have been found in numbers 30 and 40 miles away from the source of breeding; house mosquitoes (*Culex pipiens*), 2½ miles from areas of intense infestation; and fresh water swamp mosquitoes (*Aedes sylvestris*), 7 miles distant from the point of emergence. The data concerning the flight of *Aedes sylvestris* were principally obtained during May, 1917, by Headlee[1] in the Upper Passaic Valley.

During the summer of 1925, there occurred again in the Upper Passaic Valley, an emergence of upland breeding mosquitoes (mostly *Aedes sylvestris*) of tremendous proportions. It must be stated, however, that this brood was of local intensity, being confined largely to the Slough Brook, Canoe Brook, and Chatham Bridge meadows, whereas the 1917 infestation spread northward and included Hatfield Swamp and the Great Piece Meadows. With a brood of this size it was considered an opportune time to conduct further investigations to corroborate or contradict findings of the past A novel departure was instituted in the methods hitherto employed in New Jersey for such investigations.

Six men were stationed in the heart of the infested area, close to the points of incubation, armed with a number of large test tubes. As many live adult mosquitoes were caught as could be controlled in each tube, and were then transferred to large lantern globes screened at both ends. In all, approximately 20,000 adult mosquitoes were finally lodged in these containers. Next, with the aid of an atomizer, these mosquitoes were coated with a film of *methylene blue*. After the material had been given an opportunity to dry, the trapped mosquitoes were freed.

---

[1] Fifth Annual Proceedings, N. J. Mosq. Exter. Assoc. 1918: 104-110.

Close observations were maintained on the main brood for signs of a general migratory movement. This did not occur until 48 hours later when such a movement started, both to the north and south, in the valley. Generally speaking the valley in this vicinity runs north and south, while to the east and west are mountain ranges of considerable height with narrow passes at infrequent points. Stations were next selected at which specimens of mosquitoes on the wing were captured for later identification, at nightly increased distances from the point of release. Collections were continually made until the brood could no longer be traced and had apparently reached its outer limits. A few collections were then made in areas selected at random at more remote points on the bare possibility that stained specimens might be taken.

Apparently the flight was confined to the Upper Passaic Valley, the major portion being to the north. During the period of heavy infestation the weather was warm and clear, with extremely light winds, if any, from the south and southwest.

An idea may be gained of the tremendous density of this brood by quoting an average of the results of some of the early collections. At the point of release an average catch of 125 mosquitoes was made by each man, in 15 minutes. The size of these collections was limited only by the collectors' manual dexterity. Ten thousand specimens were captured. These are still being identified and dipped for stained specimens. This work will be completed during the present summer and additional data secured, later to be molded into a satisfactory discussion.

A general statement can be made at this time, however. The length of flight of this brood was approximately the same as during the flight of 1917 and, although it was more general north and south, rather than towards the mountain gaps of the east, this can possibly be explained by the statement that the 1925 brood, although extremely intensive, was not so extensive as during 1917.

Studies on the Changes Occurring in the Vegetation of Salt Marsh Areas

During the past few years it has been observed that vegetative changes have occurred on the New Jersey salt marsh areas, particularly in those areas that have been ditched, or diked and ditched, for mosquito control. In some instances the change in growth has been from reeds and sedges to grasses of intrinsic value, while in other instances changes of an opposite nature have occurred. The cutting of grass (mostly *Juncus gerardi,* commonly "black grass" and *Spartina patens,* commonly "true salt grass") for salt hay forms a commercial project of considerable extent. Grass-grown meadows are also less expensive to maintain from a mosquito control standpoint, for ditching of the type commonly used in this work "stands up" better and requires less maintenance than ditching in sedge bottom. Therefore, it is highly desirable to become informed on the causes for these changes in vegetation to the end that future mosquito work may protect and encourage the growth of valued grasses.

There are several angles from which this problem must be studied in order that the determining factor or factors may be established. It resolves itself chiefly, into a study of physical, biochemical, and mechanical effects upon the condition of the meadow, as follows:

Physical
  (a) height of water table
  (b) porosity of soil, size of particles, etc.
Biochemical
  (a) decay of vegetation
  (b) salt concentration
Mechanical
  (a) seed distribution (by tidal action and wind blown)

Since most of the plant life to be found on the salt marshes is not typical under other soil conditions, it was decided to attack the problem from a standpoint of salt concentration and height of water table, the other factors to be considered at a later date in order of their seeming importance.

During the latter part of the summer of 1925 areas were selected in the Mullica River section of the Atlantic County salt marsh, bearing the various types of grass and sedge in which we are interested. This is an open marsh, periodically swept by storm and perigee tides. At the same time areas were selected on the Waverly Meadow in Essex County, both on diked sections, over which the tide has not swept during the past five years, and on open meadow located nearby, similar in nature to that plotted out in Atlantic County. The desirable salt grass and rushes are apparently found only on true salt marsh where a supposedly required amount of salt is present. It was to prove or disprove this supposition that the first work in this study was undertaken. The Waverly section of the Essex marshes afforded a good subject upon which to conduct the required tests, as this meadow is a combination of diked and undiked areas.

Originally this entire meadow was undiked and similar in nature. Information from old residents in the locality assured us that prior to the diking of a large section of the marsh about 12 years ago good salt hay grew in abundance over most of its surface. Since the construction of the dike, startling changes have occurred in vegetative growth on the fenced-in areas, while the undiked area offers little or no change. The vegetation at present on the diked marsh consists mostly of golden rod and dogweed; the undiked, of true salt grass.

Typical plots were next selected within close proximity of each other on both the diked and undiked areas. Soil samples were taken from these places by cutting sods 12 inches wide and 24 inches deep and slicing off layers at 6, 12 and 18 inches. These were analyzed for chlorides, carbonates, sulfates, moisture, organic matter content and reaction. At the same time samples of water, collected in the holes from which the sods had been excavated, were analyzed for salt content. All soil analyses made in connection with these studies were prepared by Dr. Willem Rudolfs, Biochemest in Entomology. The following table shows the condensed results obtained, based on dry soil.

Difference of Salt Content of Soil in Undiked and Diked Plots

Depth	Moisture	Volume Matter	Chlorides	Sulfates	Carbonates	Reaction
			UNDIKED			
inches	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*pH*
6	80.7	35.1	5.53	0.60	.083	7.9
12	68.0	32.0	5.49	1.02	.075	7.4
18	72.6	27.4	4.80	1.56	.041	7.3
Water sample ..	....	....	1.04	0.03	.002	7.0
			DIKED			
6	31.7	46.6	0.37	1.00	.004	5.6
12	68.7	24.7	0.33	2.54	.020	5.5
18	71.0	31.8	0.42	1.13	.007	5.3
Water sample ..	....	....	0.16	0.08	.002	3.8

This table will not be discussed in detail here, as it has already been so treated by Dr. Rudolfs[1] in another publication. It will be noted, however, that the difference in water table (moisture) in the top 6 inches on diked areas is less than half that in the same zone on the undiked marsh.

A comprehensive idea of the amount of common salt present (on the basis of chlorides) in the different layers may be obtained from the following table:

	Undiked Meadow	*Diked Meadow*
6 inches	8.63%	0.58%
12 inches	8.57%	0.51%
18 inches	7.50%	0.61%
water	1.62%	0.25%
average	8.20%	0.58%

It will be seen from the foregoing table that there is more than fourteen times as much salt in the undiked meadow, to the depth of 18 inches, than there is in the diked meadow, to the same depth. Soil scientists assume that the first 6¾ inches of soil weigh about 1,000,000 pounds per acre. This figure is undoubtedly too high for these marshes, but on the basis of average organic matter content of soils Dr. Rudolfs has calculated that about 9 inches of meadow soil weighs approximately the same as 6¾ inches of garden soil. This being true the salt content of the first 24 inches would be about 225,000 pounds, or 112.5 tons per acre, in this undiked meadow, and but 16,000 pounds, or 8 tons per acre in this diked area. During the course of years that the diked section has been fenced from the tides this tremendous amount of salt has been leached out by rain water.

---

[1] Rudolfs, W. Investigations of Mosquito Problems Carried on at the New Jersey Agricultural Experiment Station During the Past Year. Thirteenth Ann. Proc. N. J. Mosquito Exter. Assoc. 1926: 33-56.

This physical change in the condition of the soil on diked meadow is responsible for the effects that have occurred on vegetative growth. Desired salt grasses grow best when a certain optimum of salt is present. When this salt is leached out, so that only negligible quantities remain, the salt grasses are replaced by plants suitable to the changed, fresher water conditions. If the process of leaching is continued for a sufficient length of time, conditions parallel to fresh water swamps result.

This leaching of salt also has a pronounced effect on the maintenance cost of mosquito control ditches. If a quantity of water is poured over some soil taken from an open marsh, it will be noticed that a fine silt is dispersed through the liquid, whereas liquid obtained from similar tests, conducted with soil of diked marsh, is comparatively free.

This shows that when salt is removed, silt and clay go also. The salt acts as a binding material. Along deep ditches the loss of salt is much greater in the side walls than in ditches of lesser depth. Theoretically, ditches half as deep will lose only half the amount of salt and clay, resulting in less bank softening and the corresponding need of ditch cleaning.

Summarized, the following definite changes occur on diked meadow:

1. Change in plant growth.
2. Fine sludge deposit in ditches.
3. Meadow shrinkage.
4. Ditch bank softening.

While these investigations were being carried on on the diked areas, similar studies were made on the Mullica River section, in this case on undiked meadow, largely undrained. This investigation will be continued. Enough data have been obtained to lead to the belief that salt concentration, or the lack of it, is chiefly responsible for the marked vegetative changes.

Ditch Cleaning Machinery

One of the greatest advances in the methods employed for mosquito control was the development of a self-contained, motorized ditch cleaning machine. Prior to the invention of this machine, mosquito drainage of salt marsh areas was increasing in footage rapidly to the point where it was becoming impossible to devote funds other than toward maintenance. With the machines' advent the maintenance cost has been cut from one-fourth to one-sixth that of hand labor, and at the same time far better work has been done. At the close of the present fiscal year, 7 of these cleaning machines were at work on the New Jersey salt marshes, being distributed as follows: Atlantic County, 3; Cape May County, 1; Middlesex County, 1; Ocean County, 1, and Union County, 1. Certain weaknesses have developed from time to time, but these are to be expected with newly devised machinery and are rapidly being corrected.

Ditch Cutting Machinery

The evolution of ditch cutting machinery on the New Jersey salt marshes began with the common spade (pl. 2, fig. 1). Then came a special form of spade of the two-man type, designed to take out at each stroke a piece of sod the width and depth of the ditch (pl. 3 and pl. 2, fig. 2). Use of the ordinary spade involved the services of two men, and the use of one of the special types required likewise two men, while the other type required the work of three men.

At least two determined attempts were early made to produce motorized ditching machinery, but it was found in practical use that these motorized machines had difficulty in competing with the special types of hand spades.

Then came the development of the plough idea of ditch cutting, the beginning of which was the work of Harold I. Eaton. The first machine of this type (pl. 2, fig. 3) had a separate power plant placed on skids. By means of anchor, cable, and drum, this power plant could pull itself from place to place. By means of cable and drum, while standing stationary, this power plant could pull a plough from its point of location up to itself. This type of salt marsh ditcher received extensive use and, although it required the services of a number of men, made speed enough to reduce the cost of ditching. Unfortunately, with the increasing cost of labor the best it could do was to keep the linear foot price of ditching at the point where it was when labor costs began to increase rapidly. Mr. Fred A. Reiley devised important modifications of the original plough, substituted for the skid power plant a Fordson tractor, and thereby materially increased the ability of the machine to cover ground, further serving to meet the increasing cost of labor (pl. 4).

The New Jersey Experiment Station, after consulting firms that were likely to have suitable machinery for the ditch cutting mosquito control purposes and finding that not one seemed to have anything really suitable, began the development of a salt marsh ditch cutting machine. First the ditch cutting unit, consisting of buckets fastened on an endless chain was built, tested and modified until it seemed to cut a satisfactory ditch at an adequate speed. Then a tractor was designed and built, and a cutting unit built along the tested lines was constructed and is now in process of attachment. The machine was not, to June 30, completed, but the general appearance of it is shown in plate 5.

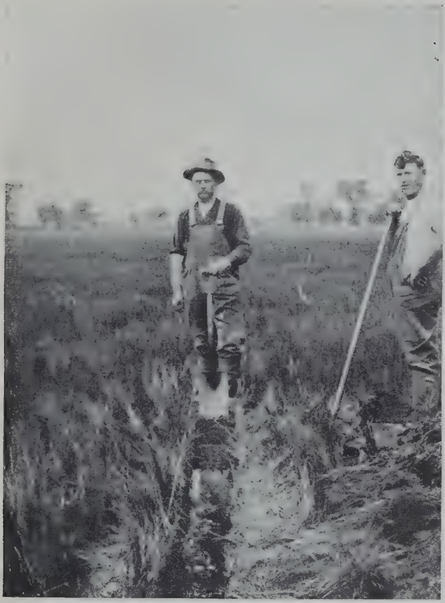


FIG. 1. EXTRA-LONG COMMON SPADE, EARLY USED IN SALT MARSH DITCHING

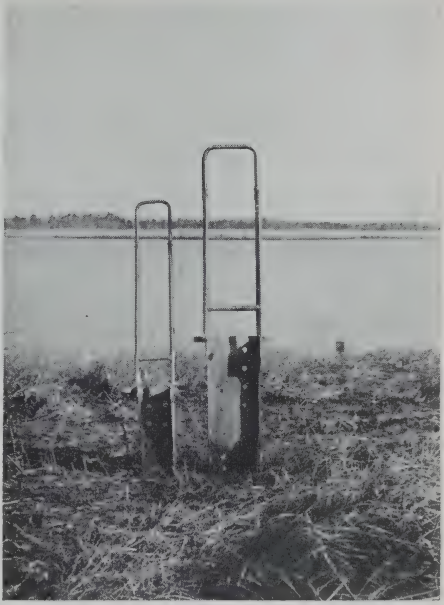
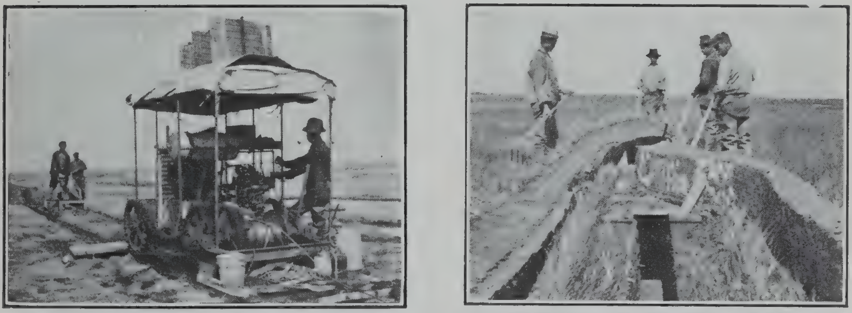


FIG. 2. SPECIAL SPADE FOR CUTTING SALT MARSH DITCHING

Spade to the right is the regular two-man spade for thirty-inch ditches. Spade to the left used for spurring



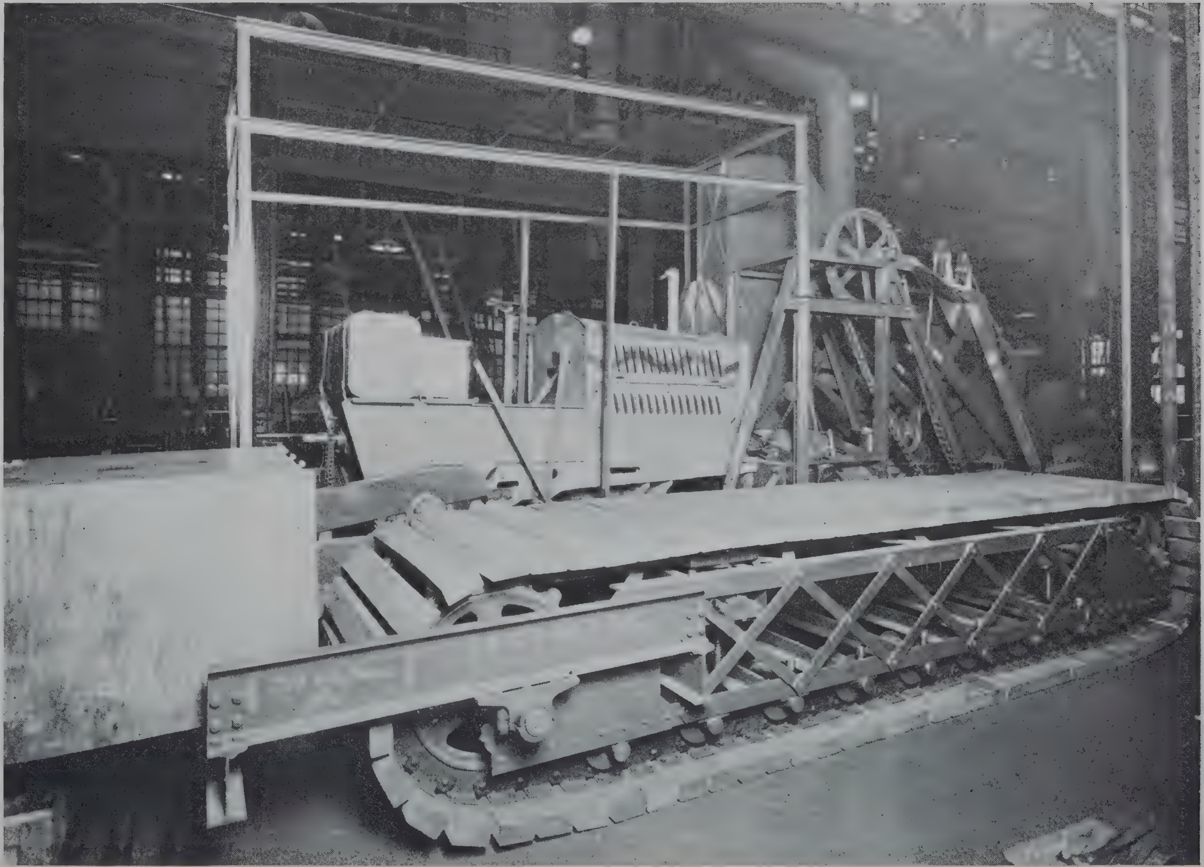
A *B*

FIG. 3. FIRST TYPE OF POWER SALT-MARSH DITCHER TO COMPETE WITH HAND SPADES, DEVELOPED BY EATON AND REILEY

A. Near and front view of power plant with plow in distance; *B*. Near and rear view of plow showing the ditch and way the sods are disposed of

(*Facing page* 244)

PLATE 5



Power Salt-Marsh Ditcher, Developed by the New Jersey Agricultural Experiment Station

Practical Work of Mosquito Control

Summarized County Mosquito Accomplishments

BERGEN

Considerable activity has been displayed in strengthening salt marsh control. New tide gates have been constructed replacing worn out gates in Sawmill and Kingsland Creeks on the North Arlington meadow and in Stump Creek, Lyndhurst meadow. Additional drainage outlet ditches have also been cut to facilitate a more speedy removal of standing water. Considerable footage of new dike was also constructed, particularly on the Little Ferry-Moonachie meadows.

On the upland, a vast amount of new work has also been accomplished. Many of the counties and municipalities entered into contracts with the mosquito commission whereby the cost of drainage was borne equally by both parties. Funds, in addition to the regular appropriation, were granted by the Board of Freeholders for the drainage of an area located in the vicinity of the county farm at Oradell and extending as far south as Hackensack. With the money thus appropriated 8 or 9 miles of ditch, averaging 8 feet in width, was redredged by hand labor and the surrounding lowlands were freed of standing water.

In addition to the new work above mentioned, thorough maintenance of all existing ditching, both on the salt marsh and upland, was carried on. During the mosquito breeding season an inspection force of sufficient size to patrol the county every 7 days, was engaged. Mosquito breeding, that could not be eliminated by more practical means, was controlled with oil.

Mosquitoes on the wing were particularly annoying during the latter part of July and August in south Bergen, especially in Rutherford. The trouble, which was caused by faulty, dishonest inspection by the local district inspector, was located. The man was immediately discharged. It was an unfortunate circumstance, but happily not a common one.

PASSAIC

The mosquito problem of Passaic, an inland county, is concerned solely with the control of fresh water mosquitoes. The two species predominating during the past year were *Aedes sylvestris* (fresh water swamp) and *Culex pipiens* (house mosquito). Since most of the county population and taxable values are located in and about Passaic, Paterson, and Clifton, most of the funds appropriated are spent in these areas.

The problem of control would be comparatively simple were it not for the vast breeding space offered by the lowlands of the Passaic Valley in the vicinity of Singac and Mountain View, and in the polluted Passaic River above the Dundee dam.

The Commission maintains an extensive inspection and oiling program in the protected zone and has succeeded in greatly reducing the mosquito nuisance. Such outbreaks as occurred last year were occasioned by mosquitoes largely bred in Morris County and in the outskirts of Passaic County not in the protected section. The conditions that existed last year, however, were foreign and ordinarily will not reoccur.

HUDSON

Several new tide gates have been installed during the past year on the salt marsh in Hudson County. A departure from the regular procedure has been instituted in their construction. Instead of the ordinary wooden gates, iron cylindrical flumes with iron gates, called "Calco Gates," have been used. Although these have not yet undergone a severe test, to date they have proved satisfactory and are much cheaper and quicker to install than wooden gates.

Much new ditching and a thorough reconditioning of old drainage systems has also been a feature of the year's activity both on the upland and on the salt marsh. Several large salt meadow areas, previously undrained or only partially drained, have been scientifically treated and are no longer sources of annoyance. The Penhorn Creek area, a large polluted meadow located in Secaucus, and a prolific breeder of *Culex pipiens,* is now in process of being ditched and tide gated.

The Commission has imported several thousand *Gambusia patruelis,* top feeding minnows of southern waters, for distribution in the ditches of the various meadows. A study is being made of their habits to ascertain whether they will survive the rigid northern winter.

The Hudson County Commission also maintains a large inspection and oiling force during the active mosquito breeding season. Much of the salt marsh in Hudson County is extremely low, some even being below sea level. Although these meadows are generally well ditched, diked and tide gated, extraordinary rains permit rapid accumulation of water, and it is at this time that a large oiling and inspection crew, such as that maintained in Hudson County, is needed.

ESSEX

Practically the entire Essex County salt marsh is protected by dikes and tide gates and the meadows are most thoroughly ditched. The chief problem is the prevention or control of ditch breeding. A large inspection and oiling force is constantly employed for this purpose. A daily patrol of all dikes and tide gates is likewise featured, practically insuring against a serious mishap arising from this source. In the Port Newark section, considerable hydraulic filling has been constantly in progress. These operations are thoroughly supervised and a watch is maintained so that the drainage of surrounding meadow land is not endangered.

On the upland, the biggest single bit of construction work was carried on the Upper Passaic Valley. Many thousand feet of main channel from the Passaic River, the principal drainage outlet, was cleared of obstructions and the water given a free flow. A considerable acreage of neighboring lowland was harnessed with ditching, outletting into the Passaic.

Unfortunately in the early part of July, 1925, extremely heavy rains occurred, especially in the mountain regions of Morris and Essex counties. In the present state of this work the abnormal conditions could not be combatted and a heavy emergence of *Aedes sylvestris* occurred, the effects of which lasted for the better part of a month.

Salt marsh mosquitoes, *Aedes cantator*, were taken in considerable numbers in night collections in and about Verona, Bloomfield, and Montclair from time to time during the breeding season of 1925. These towns are located at a considerable distance from the salt marsh, although well within the flight range of the species found. This singular occurrence became so pronounced that a state inspection was called for and made of all salt marsh areas within reach of the infested zone. Several places that might possibly have been responsible for the outbreak were found. These are now under control and are being watched with interest to note whether a similar infestation occurs this year.

The Essex County commission also maintained a large inspection and oiling force for the control of upland breeding mosquitoes and has succeeded in obtaining thus far a pleasing measure of control.

UNION

In the spring of 1925 a motorized, caterpillar ditch cleaning machine was purchased for Union County. Because of lack of familiarity with its mechanism the operators were unable to obtain the results of which this apparatus is capable. This spring, however, with the knowledge gained from last year's experience, the machine has been fairly economically and expertly handled. Figures obtained from the county commission office show that for the first 100,000 feet recut, on both long and short ditches, the cost was slightly less than one-half of a cent per linear foot. This reduces the cost of maintenance to approximately one-fourth of that of hand work and is far more satisfactory. It is expected that this cost can be still further reduced and should not exceed one-third of a cent per foot.

Considerable dike construction has been done on the North Elizabeth meadow by the commission's dredging apparatus. On the Linden meadow, spur ditching and the filling of salt holes are progressing rapidly.

On the upland the commission is maintaining the extensive drainage systems previously installed. A thorough inspection and oil control complete the major part of its field program of the past year.

MIDDLESEX

With its limited yearly appropriation of $10,000, it is impractical to attempt the control of all species of mosquitoes. Since the salt marsh types have such a wide flight range, it was deemed necessary from the outset of work in this county to eliminate such breeding areas first. Therefore, practically all funds derived from county appropriations have been directed to this end. During the past year this salt marsh program was practically completed. A ditch cleaning machine was purchased and operated successfully.

Local municipalities have been enlisted to appropriate funds for local campaigns to be spent under the direction of the county commission. Many municipalities have taken advantage of this offer.

MONMOUTH

Limited appropriations compel limited measures of control. With the funds yearly appropriated by the Board of Freeholders the salt marshes have been drained and maintained. Fresh water work is carried on in those municipalities furnishing funds for such work. The response has been fairly satisfactory.

During the latter part of the summer of 1925, following a heavy storm, the Manasquan Inlet became plugged, causing the waters to back up over the nearby lowlands. A considerable infestation of mosquitoes resulted in the nearby towns, particularly Manasquan and Point Pleasant.

OCEAN

The Ocean County Mosquito Commission is still continuing its policy of expending its entire appropriation for salt marsh work, limited appropriations being responsible. Ocean County has practically 48,000 acres of salt marsh and most of these must be drained to reasonably expect mosquito control. A ditch cleaning machine similar to those in Middlesex and Union counties was purchased during 1925 and successfully operated.

ATLANTIC

The mosquito problem in Atlantic County is chiefly one concerning control of salt marsh mosquitoes. There are practically 50,000 acres of salt marsh in Atlantic County. Practically 9,000,000 feet of mosquito drainage ditches have been cut on these marshes with many million feet still to be installed as rapidly as funds and time will permit. The problem of ditch maintenance is a serious one and to aid in its solution three ditch cleaning machines are now engaged in this type of work. An idea of the field activity of this commission during 1925 may be roughly gained by quoting a few figures: 198,650 feet of 10 by 15 inch ditching was cut by machine; 492,971 feet of 7 by 18 inch was cut by hand spade; 5,921 salt holes approximating 174,074 square feet were filled; 697,645 feet of 10 inch ditching was recut to a depth of 24 inches with the cleaning machine.

The season of 1925 was particularly difficult for mosquito control. Peak conditions existed, favoring mosquito breeding on the salt marsh. The combination of first a long dry spell followed by a period of heavy rain and the absence of high tides left the meadow depressions filled with water, but without the fish that high tides bring in. As a result, during the early part of August a large brood of *Aedes sollicitans* emerged and caused considerable discomfort. The emergence was particularly heavy in the undrained Mullica River meadows, although a great many were also incubated on the partly drained areas between the Seaview Golf Club and

Leeds Point. Migrations covered the wooded sections of the county, and in one or two instances reached Atlantic City and lower Absecon Island. At no time during the season, however, did salt marsh mosquitoes become troublesome in the central part of Atlantic City. Breeding on the drained salt marsh areas was extremely limited during the entire season of 1925 and negligible to date this year. An inspection force was maintained throughout the summer months to check upland breeding. During the year there has been no outbreaks, causing general complaint, arising from upland breeding.

CAPE MAY

Cape May is still another county with an enormous area of salt marsh, most of which requires drainage to control mosquito breeding. The limited tax ratables of the county prevent large appropriations and, therefore, the work must proceed slowly. Approximately 3,000,000 feet have been cut in the 50,000 acres of salt marsh. It is estimated that between eight and nine million more will be required to complete control. During the past year at the request of the County Chamber of Commerce and the County Mosquito Commission a survey was made by the State Experiment Station to ascertain the amount of money and work required to eliminate salt marsh mosquitoes in Cape May County. Plans for a county bond issue are now in progress of formation and it is possible that action in this direction will be taken.

Municipal Work

BURLINGTON CITY AND TOWNSHIP

Under the auspices of the Burlington Women's Civic League and the Edgewater Park League of Women's Voters a local campaign for the control of mosquitoes was carried on during 1925 and is in progress during the current year.

As in the past, considerable difficulty was experienced in the control of the city sewer beds. These beds breed prolifically, starting about June 15, and continue throughout the remainder of the season. Various oils and larvicides were applied from time to time in an effort to secure a satisfying agent of control. After thorough tests it was found that kerosene obtained from the Standard Oil Company gave best results. During the height of the breeding season of 1925 it became necessary to change inspectors. The new man, formerly employed by the Gypsy Moth Bureau, Department of Agriculture, proved very satisfactory and has again been employed this year. Except for one outbreak occurring during the middle of August the mosquito nuisance was greatly reduced, while to date this year mosquitoes on the wing have been markedly absent. Favorable comment on the campaign being conducted by these Women's Clubs is becoming more and more frequent. Such favor is also, in a few instances, taking a concrete form in the nature of volunteer funds donated to assist the further carrying on of the campaign.

Tabular Statement of the Mosquito Work From the Beginning to the End of the Season of 1925

County	Area		Population in 1925	Net valuations in 1925	Appropriations		Funds-received outside sources	New Ditches Cut		Ditches Cleaned
	Salt Marsh	Upland			Maximum Amount Possible	Amount Received		Salt Marsh	Upland	Salt Marsh
	acres	*acres*								
Atlantic	48,894	315,266	Standing 88,000 Summer 450,000	256,882,076	63,678	45,000	......	8,693,800* 227,278	....	2,000,000
Bergen	8,376	144,474	330,000	301,485,391	75,371	35,500	7,753.11	1,702,618* 89,496	1,136,650* 77,345	144,860
Cape May	49,998	8,650	45,000	64,224,620	16,056	15,000	......	2,712,079* 300,968	....	1,000,000
Essex	3,000	77,600	750,000	1,127,917,157	282,479	74,700	2,220.00	670,000*	663,000* 22,383	669,490
Hudson	9,940	15,786	658,200	1,022,353,182	255,590	63,000	2,500.00	1,291,784* 122,000	45,000* 1,800	719,000
Middlesex	8,300	156,776	162,334	159,416,446	36,000	10,000	1,407.22	1,750,000* 46,500	52,000* 10,000	......
Monmouth	3,778	340,902	123,000	153,404,948	37,608	7,800	300.00	609,676* 10,655	3,190* 550	282,578
Ocean	47,732	360,171	23,011	33,168,669	16,584	16,000	250.00	6,278,955* 300,909	....	25,000
Passaic	....	122,600	249,917	361,231,521	90,308	16,000	......	....	25,000* 3,800	......
Union	4,000	61,717	225,000	330,508,244	82,000	40,000	2,516.68	1,071,843* 29,000	1,200,000* 18,627	351,600

County	Ditches Cleaned	Salt Marsh Ditches Cleaned, 1925	Ditches Recut by Machine	Tide Gates		Dikes	Acres Drained by Pumps	Amount of Oil Used		Amount of Larvacide Used		Percent of Total Area Under Control	
	Upland			Sq. ft. Cross Section	Acres Drained			Salt Marsh	Upland	Salt Marsh	Upland	Salt Marsh	Upland
Atlantic	......	*per cent* 27	697,645	..	....	....	....	....	350	None	30	54	1.3
Bergen	177,865	36	......	24	5,260	6,206	....	1,550	12,468	None	60	95	90
Cape May	......	..	......	..	1,800	....	....	....	108	None	..	50	..
Essex	640,081	100	......	..	2,300	....	....	10,601	15,433	None	..	100	80
Hudson	6,600	100	......	18¼	3,632	....	1,225	16,900	11,650	None	..	84	100
Middlesex	52,000	10	118,375	..	....	....	....	....	30	None	..	95	..
Monmouth	39,450	90	......	..	....	....	....	1,897	405	None	..	90	5
Ocean	......	..	100,000	..	....	....	....	100	....	None	..	..	..
Passaic	20,000	..	......	..	....	....	....	....	14,190	None	15	..	37
Union	383,830	38	60,000	..	2,500	8,370	....	320	8,218	None	..	100	90

Note—Numerals followed by an (*) represent totals from the beginning of work to 1925.

Mosquitoes of the Year

During the spring and early summer months, both mosquito breeding and mosquitoes on the wing were markedly absent in the protected zones. This absence of the pest cannot be attributed solely to favorable weather conditions, for observations indicated that the unprotected areas were throwing off the usual broods, with their attendant discomfort.

Starting with the latter part of June, however, weather conditions underwent a severe change. The rainfall was particularly heavy, with the result that the various organizations engaged in mosquito control were unable to expand (mostly because of lack of emergency funds) to meet the unusual conditions. Every depression and receptacle, ordinarily dry, became a water holder and bred mosquitoes. Even the drained salt marsh areas were not immune. Early in the year, many of the ditches had drained dry, but with the coming of the rains, sufficient water was held, pooling along the bottoms. Mosquito breeding followed. The Upper Passaic Valley was also hard hit. The Essex County Mosquito Commission had redug, each year, a great many of the drains in the low lying meadows situated in the valley on both sides of the Passaic River and had cleaned obstruction from the river bed to further reduce the water level. This work had been of great benefit. Unfortunately, however, the Rockaway River, tributary of the Passaic, which has its headwaters in the mountains to the west, empties at practically right angles into the Passaic. Draining as it does from the mountainside, its flood waters gained such momentum that when entering the Passaic they practically formed a water dam, compelling the Passaic to back over the surrounding low lands of the valley. An enormous brood, mostly *Aedes sylvestris,* emerged and infested the neighboring zone.

Despite the abnormality of the situation the County Mosquito Commissions did yoeman work and succeeded to a large degree in keeping down the pest.

With the disagreeable experience of 1925 in mind, the Commissions were urged to set aside certain funds in their budgets for 1926 to permit of an expansion of working force should the need arise.

Educational Work

Successfully to combat mosquitoes the general public must be educated as to the practicability of a campaign, and its economic value together with the increased measure of comfort afforded. The public must also be informed in the ways in which it may help the field workers; such as eliminating man-made breeding places and supporting the recognized agencies of control with public sentiment. Such educational propaganda is extensively carried on by the various mosquito fighting organizations in New Jersey by means of pamphlets, manuals, newspaper articles, lectures, and motion pictures.

The New Jersey Agricultural Experiment Station has strongly urged this important feature of control and has taken an active part in it. During the past year lectures and talks were given before the following organizations:

Burlington League of Women Voters
Burlington Civic Club
Woodbridge Women's Club
Essex Fells Parent Teachers' Association
Dover Women's Club
Boonton Women's Club
Oradell Women's Club
South Amboy Rotary Club
Cranford Women's Club
Pompton Lakes Chamber of Commerce
Irvington Parent Teachers' Association
South Bergen Literary Society
New England Society, South Orange
Sewaren History Club

At these lectures and talks, the motion picture reel, entitled "Warfare Against the Mosquito in New Jersey," was shown whenever possible. "Mosquito Manuals" and other printed materials were disseminated to aid in pressing home the message.

Lectures were also given to the sanitary officer's classes during the summer session of the State Board of Health held at Rutgers College, New Brunswick, in 1925.

Newspaper and magazine articles were prepared from time to time to keep the public informed. The "American City" printed an article on practical mosquito work that was far-reaching, since this magazine has a wide circulation among city, county, and state governing officials.

A committee was also formed during the past year in the Associated Executives to revive the radio lectures.

At the annual meeting of the New Jersey State Mosquito Extermination Association glowing reports were received from representative speakers of the New Jersey State Federation of Women's Clubs. In the course of the year practically every club had been visited by a speaker who had discussed from some angle the mosquito or had distributed literature.

To date, the 1926 season can truly be called "the best ever." Mosquitoes on the wing have been negligible in the metropolitan district and scarcely more prominent in the remainder of the protected zone.

State Inspection

In July, 1925, a meeting of the metropolitan county mosquito executives was called by the field representatives of the Essex County Mosquito Extermination Commission to determine the areas responsible for the breeding of salt marsh mosquitoes caught in night collections at various inland parts of Essex County.

As a result of this meeting, the State Experiment Station was petitioned to make a survey of the entire salt marsh area located in the counties of Bergen, Hudson, Essex and Union, the expense incurred to be borne by the aforementioned counties. In order to make a quick, and at the same time, thorough sweep, competent inspectors were borrowed from the Gypsy Moth Bureau of the United States Department of Agriculture. These inspectors were directed by this Station.

The inspection revealed defects both in actual drainage work and in inspection. These were presented to the mosquito commissioner in the counties in which they were found. These findings were well received and immediate steps taken to remedy the reported failings.

At the request of these counties, the station has employed an inspector for this year for the summer months who is now engaged in checking conditions on these marshes. This inspection serves to keep the station well informed on existing conditions and give the county supervisors a check on their inspectors. It is an important and practical move.

New Jersey State Federation of Women's Clubs

This large, powerful organization has taken a deep interest in mosquito control for a number of years and has been a factor in the success that has been attained; largely through its publicity bureau has assistance been given. There is scarcely a club woman in the Federation, numbering about 35,000, who has not been thoroughly informed on the subject. Education of such proportions is of inestimable value. Whenever requested, and the requests have been many, the station has shown the motion picture reel, "Warfare Against the Mosquito." The Federation has also agreed to conduct a state-wide mosquito essay contest in the schools and will award prizes to county and state winners.

New Jersey Mosquito Extermination Association

The thirteenth Annual Convention of the New Jersey Mosquito Extermination Association was held at the Hotel Traymore, Atlantic City, on February 17, 18 and 19 of this year, and was well attended. Men, prominent in mosquito work and other entomological endeavors, presented excellent papers. Among the most prominent speakers were Dr. L. O. Howard, chief, Bureau of Entomology, United States Department of Agriculture; Mr. Arthur Gibson, dominion entomologist, Canada; Mr. Arthur Stringer, assistant director, Gorgas Memorial Institute; and Dr. Frederick Hoffman, chief statistician, Prudential Insurance Company. The station was represented by Dr. Lipman, Dr. Headlee, Dr. Rudolfs and Mr. Miller. The evening session on the eighteenth was broadcast through Station WPG, the Municipal Broadcasting Station of Atlantic City. Two thousand copies of the proceedings of the meeting were printed and distributed among the mosquito commissions, other organizations and individuals interested.

Associated Executives of Mosquito Control in New Jersey

This organization, which consists of the executives of the county mosquito commissions together with representatives of the station, has held its usual monthly meetings during the past year. The purpose of the meetings is to exchange ideas and to confer on common problems through the medium of committees or general discussion.

Report of the Extension Service

H. J. BAKER

ADMINISTRATION

Reorganization Cuts Overhead Cost

The plan of administration of the Extension Service which was put into effect three years ago has finally resulted in changes which have reduced the cost of administration and supervision $15,000.00 a year. The administrative staff has been reduced until at present it consists of only a director and two assistant directors. One assistant director supervises all agricultural work with both adults and juniors and one assistant director supervises all home economics work with both adults and juniors. Girls' club work is now assigned to the county home demonstration agents who are best qualified to conduct this extension activity. This allows the men county club agents to devote their full time to boys' club work for which they are especially fitted. This change is a logical development of the changed plan of administration. Girls' club work now requires less supervision from the state extension office, and consequently further lowering of overhead cost has resulted.

Closer Coordination of Extension Activities

In addition to this reduction in overhead expense, the extension work in its several branches is now more closely coordinated and is correspondingly more efficient and effective from the standpoint of serving the agricultural interests of the state.

Improvement in Plans of Extension Work

Progress has been made during the past year in planning the work of the extension staff on a more definite and constructive basis. More careful planning of extension activities has directed the extension work to the most fundamental problems, has enabled the staff to do more work, has reached more people, has resulted in more specific and greater accomplishment in building the foundation on which the future prosperity of agriculture must rest.

The progress in reducing the overhead cost of administration in coordinating extension activities and in perfecting plans in extension work has come as a result of careful study of methods and results, and a conscientious, loyal, efficient staff of extension workers. The morale of the extension staff has been strengthened and built up to a high standard.

Cooperation in Conducting Extension Work

The Extension Service in Agriculture and Home Economics is conducted cooperatively by the New Jersey Agricultural College and Experiment Stations, the United States Department of Agriculture, and the County Boards of Agriculture.

The cooperation with the county boards of agriculture and with the United States Department of Agriculture has continued harmonious. The executive committees of the county boards and the county home economics executive committees have held regular meetings, in most counties once a month, to advise with the county extension agents in conducting their activities. It is the administrative policy for the extension director and the assistant directors to attend as many of these county extension meetings as possible, and during the year several meetings have been attended in each county by the administrative officers. The success of extension work is in a large measure due to the cooperation of these county extension committees with the members of the extension staff in planning the county extension activities.

The Extension Staff

County extension agents, including agricultural agents, home demonstration agents, and boys' and girls' club agents, are maintained in the counties with headquarters at the county seat. Eighteen counties have agricultural agents, twelve counties have home demonstration agents, and ten counties have boys' and girls' club agents.

Extension specialists in agriculture and home economics assist the county workers. The Extension Service has agricultural specialists in dairy, poultry, farm crops, vegetables, fruit, farm management, and part time in agricultural engineering and in forestry; and home economics specialists in foods, clothing, and home management. The extension specialists have headquarters at the Agricultural College in New Brunswick.

FARMERS BELIEVE IN EXTENSION WORK

A survey to find out what farmers think of extension work was conducted in 1925, during which 621 farms were visited. Sixty-nine per cent, or nearly 7 out of every 10 farmers, believe in the Extension Service, and 64 per cent have changed their farm practices as a result of extension work. Only 3 per cent of the farmers, or 3 out of every 100, were opposed to the Extension Service.

Agriculture

The following is a statistical summary of the extension activities in agriculture for the year 1925:

15,633	farm visits made during year
6,124	different farms visited
1,617	extension meetings held
73,500	people attended these meetings
32,813	individual letters written
12,766	office calls by farmers in relation to their farming problems
22,022	telephone calls by farmers to county agents
991	circular letters written
293,541	total circulation of circular letters
2,984	news articles written
315	communities in which extension work was conducted
922	local leaders assisted in extension work

Agricultural extension work in 1925 was conducted mainly in the following branches of farming:

Agricultural Engineering

1. Drainage
2. Farm building construction and rebuilding
3. Farm and home sewage disposal
4. Care and use of farm machinery

Farm Crops and Soils

1. Improvement of varieties and strains
2. Use of fertilizers
3. Use of cover crops and green manure
4. Alfalfa and other legumes

Farm Management

1. Farm accounting
2. Study of relation of cropping practices to market conditions and crop forecasts
3. Balancing of farm practices to meet conditions

Forestry

1. Care and development of the farm woodlot
2. Reforestation of lands unsuited to agriculture

Fruit Growing

1. Pruning demonstrations with peaches, apples, grapes, and other fruits
2. Control of insects and diseases
3. Cultural methods and fertilizer demonstrations
4. Demonstrations of best varieties
5. Spray card service

Poultry

1. Breeding
2. Disease control
3. Flock management
4. Marketing problems

Vegetable Growing

1. Soil improvement, fertilizer, and cover crops
2. Control of insects and diseases
3. Standardization of varieties
4. Improvement of marketing conditions
5. Improvement or production through seed selection

HOME MAKERS BELIEVE IN HOME ECONOMICS

Sixty-four per cent of the home makers are favorable to home economics extension work, according to a survey made in 1925. As a result of extension teaching 41 per cent of the village homes and 15 per cent of the farm homes have adopted improved practices in home making.

Home Economics

The home economics extension work is devoted to:

1. Balanced meals for the family and proper feeding of children. This means better health.
2. Clothing problems, which include lessons and demonstrations in making dresses and hats, children's clothing, and selection of material. This means economy in the cost of clothing the family and at the same time being more appropriately dressed.
3. Home management, including organizing the household tasks for greatest economy of time and effort, renovating floors and furniture, proper heights of tables and sinks, and best arrangement of the kitchen—a workshop of the home—to save labor, and installation of labor-saving

> devices. This is applying the same good management practices to the problems of running the home as are applied to successful management of the farming business.

The records of home economics extension activities in 1925 are as follows:

269 communities carried on a home economics program
1,007 communities participated in home economics extension work
1,298 women acted as community leaders in helping extend this information
2,642 home visits were made by home demonstration agents
15,772 individual letters written
275 training meetings for leaders were held by extension specialists
2,220 women attended these meetings
2,170 extension meetings were held
48,574 women attended these meetings

The different activities of the Extension Service in home economics include the following:

Clothing

1. Dress construction; the use of the sewing machine
2. Use of commercial patterns; their alterations and the making of permanent patterns
3. Dress design
4. Millinery and hat trimmings

Foods

1. Food selection and preparation for health
2. Food studies for mothers of small children
3. Preservation and use of home-grown foods for the family diet

Home Management

1. Kitchen arrangement and equipment
2. Floors, floor coverings, and renovation of furniture
3. Lighting and ventilation
4. Organizing household tasks for efficiency and health

There are 1,298 local women who cooperate with the county home demonstration agents and the home economics extension specialists in spreading the extension teaching in their respective communities. They attended training classes conducted by the home economics specialists and assisted the county home demonstration agents in holding meetings, in answering personal inquiries, and in conducting demonstrations. The local leaders devoted, on an average, 10 days' time to extension work during the year. This has been a most valuable contribution to their communities and has enabled the extension workers to reach thousands of homes which otherwise would not have been served.

BOYS' AND GIRLS' CLUB WORK

The Extension Service conducts work with young people in agriculture and home economics. These clubs include raising dairy calves, swine, poultry, gardens, vegetables, crops, sewing, canning food, cooking, preparing and serving meals, making their own clothes, and personal health.

The following is a summary of the boys' and girls' club work for 1925:

17	counties conducted boys' and girls' club work
270	total number of clubs
3,450	total enrollment
1,048	meetings held
17,192	people attended these meetings
235	local leaders assisted in junior work
6,095	farm visits made by county club agents
1,816	different farms visited
7,637	individual letters written
981	office calls
3,140	telephone calls

All the boys' and girls' clubs have local leaders who are interested in helping the young people of their communities, and as a rule each club has monthly meetings. The local leaders contribute their services, attend the club meetings, and give encouragement and help to the individual boys and girls in carrying out their projects.

The following is a classified list of clubs with the enrollment:

Number of Clubs	*Kind of Club*	*Enrollment*
31	Dairy Husbandry	361
40	Poultry Husbandry	381
12	Swine Husbandry	51
2	Fruit Growing	12
11	Vegetable Growing	106
	Farm Accounting and Management	7
8	Corn (seed)	137

		Enrollment	
Number of Clubs	*Clothing*	*Home Management*	*Food Preparation*
166	1500	311	434

GENERAL ACTIVITIES

Agricultural Program

The Extension Service, the Experiment Station, the State Department of Agriculture, the State Commission on Conservation and Development, the State Federation of County Boards of Agriculture, and the State Grange are cooperating in a study to outline an agricultural policy for the State of New Jersey, looking to the future development of a profitable farming business and making the greatest possible contribution to the food supply of the state. This study has been going on for about a year, and preliminary reports are being prepared.

Agricultural Conferences

Bankers' Convention

A convention of bankers interested especially in agriculture was held in December at the Agricultural College. The program consisted of a discussion of experimental work, extension activities, and consideration of an active program for the bankers in cooperation with the Extension Service. The bankers' agricultural program for 1925 was as follows:

1. Better quality dairy stock.
2. Encourage farmers to buy on cash basis.
3. Encourage farmers to get their farm mortgages on long-term credit basis on amortization plan—Federal Land Bank or Joint Stock Land Bank loans.
4. Encourage cooperative organization on economic basis and sound business management.
5. Endorsement and encouragement of boys' and girls' club work in agriculture and home economics conducted by the Extension Service of the State Agricultural College.
6. Farm accounts.

In the spring of 1925 the chairman of the Agricultural Committee of the State Bankers' Association and the director of the Extension Service visited sixteen counties for conference with bankers and county agents for the purpose of developing closer cooperation between bankers and the county extension agents.

Feed Dealers' Conference

The feed men of New Jersey have held three annual conferences at the New Jersey Agricultural College. The Extension Service has assisted in organizing these conferences, believing that by conducting an educational program of benefit to those who supply feed to farmers, a valuable, though indirect, service to agriculture is being rendered. Those engaged in business allied to agriculture are rendering a real service to farmers, and the more efficient their service, the better for agricultural prosperity. In 1925, 168 feed dealers attended the annual conference.

Boys' and Girls' Encampment

An annual encampment of boys and girls in club work has been held at the Agricultural College for years. In June, 1925, there were 244 in attendance for the 3-day period. This encampment is a reward for those who have done successful club work. The program is educational and it also acquaints the boys and girls with Rutgers University, especially the Agricultural College and the College for Women. This initimate acquaintanceship with the University enables the boys and girls to decided more wisely whether they wish to pursue further study by getting a college education.

Exhibits

The Extension Service cooperated with the Trenton Fair by making exhibits of boys' and girls' club work in agriculture and home economics. In 1925, this exhibit included 146 dairy calves, 192 swine, 339 head of poultry, and exhibits in foods, clothing, and home management. The boys and girls in club work conducted demonstrations at the fair. The legislature of 1925 made an appropriation of $10,000 for two buildings at the Trenton Fair grounds for the boys' and girls' club exhibits. These buildings are 30 by 200 feet and 36 by 100 feet respectively. In addition to these buildings a tent was provided for the poultry and swine exhibits. It is not too much to say that this exhibit of the boys' and girls' club work is one of the best exhibits at the fair. The livestock exhibited at the Trenton Fair in 1925 by boys and girls in club work took $1,135.50 in prizes. The dairy club animals at the National Dairy Show took first with the Holstein herd; first with the Guernsey herd; first with the Jersey herd; first in showmanship. Eight states were in competition, including the best dairy states in the country.

FINANCES

The Extension Service is financed by appropriations from the state; the Federal Smith-Lever extension appropriations; appropriations from the United States Department of Agriculture; and appropriations by the County Boards of Freeholders.

COOPERATION OF FARMERS' ORGANIZATIONS

The farmers' organizations of the state are loyal supporters of the Extension Service and many extension activities are conducted cooperatively with the several organizations. This cooperative spirit is mutually advantageous and especially makes more efficient the efforts of the Extension Service.

Report of the Division of Horticulture

M. A. Blake

The year July, 1925, to July, 1926, was marked by progress in horticultural research, particularly in peach breeding. The latter project has now reached a point where marked results are likely to be forthcoming every year. Apple pollination studies were taken up as a new field of investigation and valuable information was obtained the first season. Progress has been made in cultural work with strawberries. The source of plants and their early setting have proved to be important factors in securing a good stand of vigorous plants. The appointment of Dr. G. T. Nightingale to the staff on October 1 will enable the division to conduct some much needed work of a biochemical and plant physiological character.

The plant-food investigations with asparagus, sweet potatoes, tomatoes, carrots, celery, cauliflower, and peppers have now been continued for several seasons and are giving consistent results.

As special demands are being made upon the division for more research with ornamental plants, this work is gradually being extended.

Fiftieth Anniversary Meeting of the New Jersey State Horticultural Society

The New Jersey State Horticultural Society was organized at Geological Hall, Rutgers College, August 17, 1875. On August 17, 1925, the society held in the same room and building a celebration of the fiftieth anniversary of its organization.[1]

This meeting is briefly mentioned here because the society takes such an intimate interest in the investigational work of the division of horticulture and results of investigations are presented at its sessions and in its publications.

Second Shipment of Peaches to New Zealand

On November 23, 1925, another shipment of station seedling peaches was started on its journey to Auckland (New Zealand), for a test upon the grounds of Mr. H. R. Wright. The list of those sent is as follows: 2 Buttercup, 2 Cumberland, 2 Delicious, 2 Primrose, 2 Radiance and 2 Rosebud. Mr. Wright reported in February that, although the trees were in transit for an exceptionally long period, all were in good condition and would grow.

Split-Pit Peaches

Freestones Preferred.—Consumers in the cities and towns along the Atlantic seaboard have a decided preference for freestone peaches or those varieties whose flesh may be readily parted from the stone or pit, when the fruit is mature. A ripe peach may be eaten with more satisfaction and enjoyment if it can be broken in halves and the stone easily removed. Even the very appearance of the flesh as it breaks from the pit freely is enticing. Freestone peaches can also be sliced and prepared more readily for the table than clingstones. A freestone peach whose pit splits apart so that it is necessary to remove each half from the flesh is not nearly so objectionable as a clingstone, but peaches that have split-pits are a disadvantage. In the case of the most advanced forms of split-pit, the fruits are abnormal in form, are likely to ripen a few days in advance of normal fruits, do not pack and ship so well, and are not liked by consumers. The Pacific Coast canners of clingstone peaches object to using them; in fact, they must be separated out from the best grade of peaches for canning. B. E. Maynard, of San José, California, reports[1] percentages of split-pits on Tuscan Cling peaches ranging from 3.23 to 43.24 per cent on different fertilizer plots. Split-pit specimens are excluded from packs of peaches intended for export from New Zealand and South Africa.

---

[1] A detailed account of the event is printed in the *Horticultural News* for August, 1925, pages 119 to 126.

Nature of the Injury.—In pronounced cases of split-pit, the two halves of the stone have separated along the suture lines and the kernels act as in the case of germination. The separation may be partial or complete, and callus may form along the cleft or break in an attempt to knit or unite the divided parts. The embryo or embryos inside the stone often show an advanced state of development, sometimes even having sprouted when the fruit is ripe. All degrees of so-called split-pit symptoms may be found on a tree. In the more advanced cases the pit is so enlarged in one diameter as to make the form of the fruit easily recognized. In the less advanced cases the pit is broader along one suture than normal and the fruit is not so much off type as where the pit is actually cracked open. Mature fruits in pronounced cases of split-pit are thicker than normal fruits, or in other words, are overdeveloped in the cheek to cheek diameter. Frequently, the two halves of such fruits are so enlarged that the suture lines appear to constrict the fruit. The suture diameter of the fruit is less in proportion to the cheek to cheek diameter than in the case of normal fruits.

Dimension Ratios of Normal and Abnormal Specimens.—If we consider the length of the fruit of a peach as a unit, and figure the suture diameter and the cheek to cheek diameter in relation to the length we establish what might be termed a dimension ratio; for example, in the case of a very small fruit, if it had a length of 1 inch, a suture diameter of 0.75 inch, and a cheek to cheek diameter of 0.50 inch, the dimension ratio would be 1-.75-.50. The normal specimen of Delicious peach illustrated in figure 1 had a dimension ratio at maturity of 1-1.03-1.03, while the dimension ratio of the split-pit specimen was 1-.97-1.17. Varieties of peaches that tend to be oval in shape, such as Elberta and Belle, are not so wide and thick in proportion to their length as the so-called "round" peaches. For example, two normal specimens of Elberta at New Brunswick, N. J., in 1925, had the following dimension ratios at maturity: 1-.97-.87 and 1-.92-.88, while a typical split-pit specimen of Elberta had a dimension ratio of 1-.94-.98, showing that it was relatively larger in the cheek to cheek diameter than normal specimens.

Cause of Split-Pit.—It has been observed at the New Jersey Station that split-pit specimens commonly occur upon vigorous trees that have been girdled partially by winter injury, borers, or some other factor which interferes with the downward movement of the elaborated food. In other words, they are what is termed today as high-carbohydrate trees, but with considerable vigor. Trees may be relatively high in carbohydrates but so weak in general vigor that the fruits are small, and in such cases split-pits may not appear. Split-pits are also found upon individual branches and twigs that are injured or affected in a manner which interferes with the downward movement of the food.

When Does Split-Pit Occur?—Careful measurements of the rate of development of Elberta peaches in three dimensions secured at New Brunswick, N. J., 1925, showed that split-pit specimens were relatively larger in the cheek to cheek diameter than normal specimens as early as late June as may be noted from the figures in table 1. On July 13, 1926, an Elberta peach from a girdled tree at Dayton, N. J., showed the following dimensions when measured: length 1.76, suture diameter 1.53, and cheek diameter 1.47 inches or a dimension ratio

---

[1] *Better Crops,* for February, 1926, pages 57-58.

PLATE 1

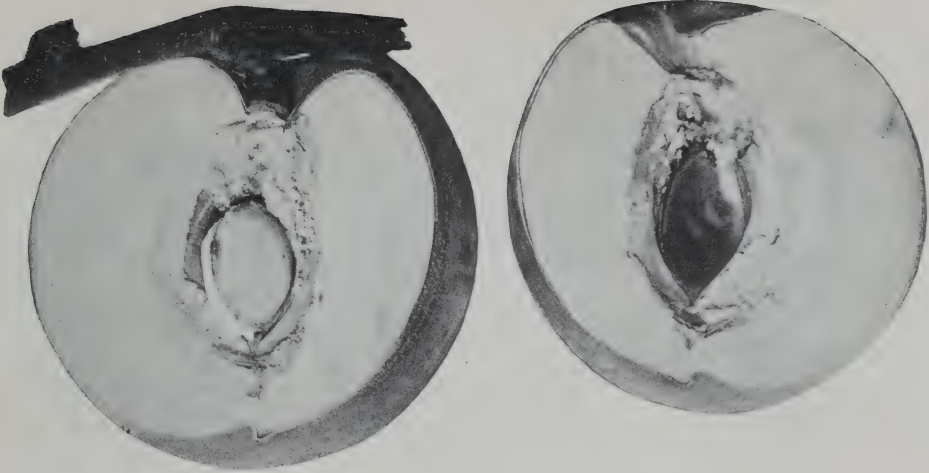


FIG. 1. SPLIT-PIT PEACH WITH KERNEL GERMINATING

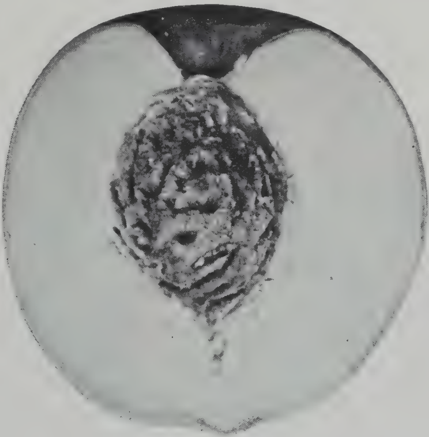


FIG. 2. HALF OF A NORMAL PEACH

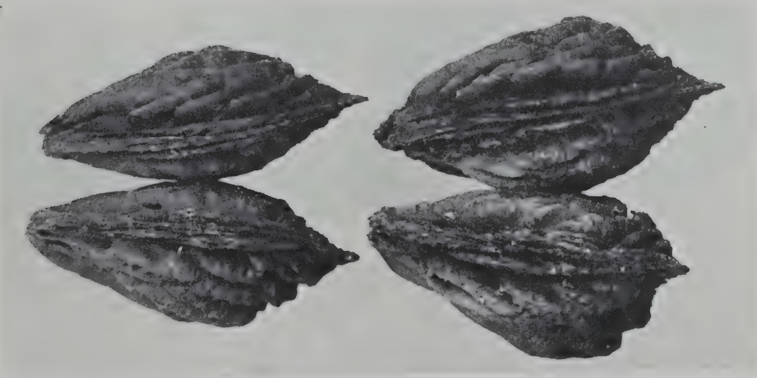


FIG. 3. (LEFT) NORMAL PIT. (RIGHT) TENDENCY TO BECOME SPLIT-PIT
Both are of the Elberta Variety

PLATE 2

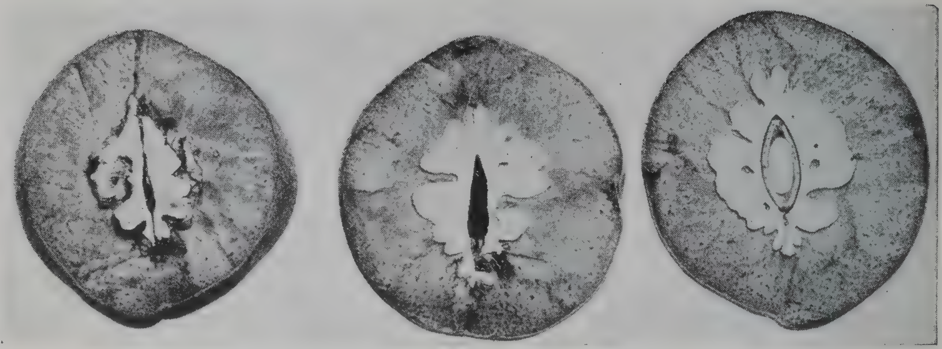


FIG. 1. GREEN J. H. HALE PEACHES IN JULY, WITH PITS SPLITTING JUST AS THEY ARE HARDENING

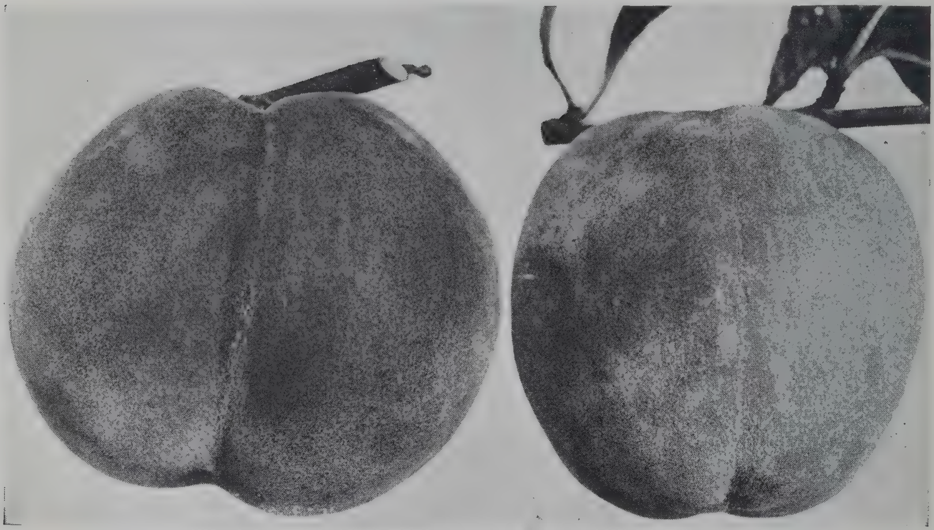


FIG. 2. (LEFT) SPLIT-PIT PEACH. (RIGHT) NORMAL SPECIMEN. *Both are of the Variety Delicious*

of 1-.87-.835. The pit at that time with some effort could be cut through with a knife. A cross section showed that the two halves of the pit were beginning to separate along the line of the deepest part of the suture. Specimens of the J. H. Hale peach from a partially girdled tree at Middletown, N. J., were gathered on July 17, while the pits could still be whittled through and various degrees of splitting of the pits were clearly demonstrated in the cross sections. In other words, the forcing effect of the large food supply made available to the fruit takes place early in the season, before the pits have become hardened. Split-pit peaches are, therefore, the result of nutritional conditions in the tree early in the season. The largest fruits are the ones most commonly affected If the pits are normal until they have become thoroughly hardened, there will be no split-pits.

Excess Rainfall Not Responsible.—The cause of a large number of split-pit fruits at maturity is sometimes said to be an excess of rainfall just previous to the maturity of the fruit. Such can hardly be the case. Split-pit specimens may attain a larger size, the flesh may be more watery, and the fruits less desirable if the weather just before the maturity of the fruit is wet rather than dry.

Can Split-Pit be Controlled or Prevented?—Where peach trees are kept growing normally, so that an excess of carbohydrates and other foods is not sent into the fruits, there should be a very small percentage of split-pits. If the trees tend to become checked in growth by winter injury or other factors. stimulation by means of available plant-foods may help to overcome the difficulty. In the east, however, injury or checks which are sufficient to cause split-pit fruits are usually of such a nature that applications of plant-food, especially nitrogen, may not modify growth sufficiently to change the nutritive status in the tree to a degree that will prevent split-pits, in any one season. If the trees can be gradually brought to a normal nutritional condition by tillage and applications of plant-food the tendency toward production of split-pit may be overcome.

Rate of Growth of Individual Fruits of the Peach

The season of 1921 was one of the earliest ever experienced at New Brunswick since horticultural records have been kept. Peaches began blooming the last few days of March instead of from the latter part of April to the first of May, which is usually the case.

Mr. C. H. Connors took measurements of the rate of growth of the fruits

TABLE 1

Ratios of the Three Dimensions of Two Normal Specimens and One Split-Pit Specimen of Elberta Peaches, New Brunswick, N. J., 1925

	Series I. Twig 3	Series III. Twig 5	Series III. Twig 4
Date	Fruit 6 Normal Specimen	Fruit 4 Normal Specimen	Fruit 1 Split-Pit Specimen
June 8......	1- .81- .64	1- .77- .67	1- .83- .69
June 15......	1- .82- .69	1- .80- .70	1- .83- .70
June 23......	1- .83- .68	1- .82- .73	1- .84- .73
June 30......	1- .84- .70	1- .82- .75	1- .84- .74
July 6......	1- .84- .74	1- .81- .74	1- .86- .76
July 23......	1- .87- .75	1- .83- .77	1- .87- .79
July 27......	1- .88- .78	1- .84- .78	1- .89- .80
Aug. 5......	1- .90- .82	1- .90- .84	1- .91- .87
Aug. 11......	1- .91- .81	1- .88- .83	1- .89- .88
Aug. 19......	1- .93- .85	1- .93- .85	1- .94- .94
Aug. 24......	1- .99- .87	1- .92- .84	1- .92- .94
Aug. 27......	1- .96- .89	1- .90- .85	1- .94- .96
Aug. 29......	1- .97- .88	1- .92- .87	1- .94- .98
Sept. 1......	1- .97- .87	1- .92- .88	1- .94- .98

of several varieties of peaches in three dimensions during that exceptional season. The drop of fruit was heavy and the number of typical fruits which might have been averaged was small, but the data have been compiled upon a few typical individual fruits and it is believed that they fairly represent the rate and nature of the development of growth of typical fruits of the variety during the season of 1921 at New Brunswick.

These data are from the original notes taken by Mr. C. H. Connors.

Blooming Dates of Peaches—New Brunswick
March and April—Season 1921

Variety	*Date First Bloom*	*Date Full Bloom*
Arp	April 2	..
Belle	March 28	5
Carman	March 28	6
Early Wheeler	April 2	5
Elberta	March 27	5
Foster	March 28	4
Greensboro	April 2	6
Hiley	March 28	5
Iron Mountain	April 3	6
Japan Dream	March 27	..
J. H. Hale	March 28	6
Krummel	April 3	6
Lola	April 3	..
St. John	April 2	4
Bangert's Nect.	March 28	6

Individual buds were not tagged and the fruit of each was not followed through to maturity, but individual fruits were selected, tagged, and measured, beginning at a very early stage. The approximate date of the bloom of the individual fruits is also known, so that the number of days from bloom to any given date of measurement is approximately correct.

Rate of Growth of One Elberta Fruit

The date of bloom of this fruit was estimated to be March 30 and the days from bloom to the various dates of measurement are figured upon this basis. It is of interest to note that even in the very early blooming season of 1921 the fruit of Elberta attained its most rapid rate of growth from about the middle to the latter part of May as it usually does.

Rate of Growth of J. H. Hale Fruits

The growth meaurements were also determined for two J. H. Hale fruits, number 1 and number 2. The date of bloom of fruit number 1 is estimated as March 29 and of number 2 as March 30. Both were large fruits which attained a cheek diameter of more than 3 inches at maturity. By comparison with the dimension ratios of the Elberta fruit it will be noted that the J. H. Hale is more round even at an early date.

Some Carman fruits were also measured during the season of 1921, and the data upon 4 different fruits are published here. The blooming date of fruits numbers 1, 2, and 4 is considered to be March 29, and of fruit number 3, April 1.

Carman, when well developed, may be classed as a round peach. In some seasons like that of 1925 at New Brunswick the fruits may be round oblate. Of the 4 fruits measured in 1925, number 2 is the more oval. Carman made a rapid growth from May 16 to 24 and for the last 10 to 15 days before maturity.

TABLE 1

Rate of Growth of Elberta—Season 1921

Date Measured	Days from Bloom	Length	S. Diameter	C. Diameter	Rate of Growth per Day			Ratio of Three Dimensions		
					L.	S.D.	C.D.	L.	S.D.	C.D.
				FRUIT NO. 1						
4-29	30	0.36	0.26	0.24				1	.72	.67
5-9	40	0.60	0.42	0.35	.0250	.0160	.0110	1	.70	.58
5-16	46	0.92	0.66	0.55	.0450	.0340	.0280	1	.72	.60
5-24	54	1.37	1.01	0.84	.0560	.0430	.0360	1	.74	.61
5-31	61	1.65	1.29	1.11	.0400	.0400	.0380	1	.81	.67
6-7	69	1.83	1.47	1.25	.0250	.0250	.0200	1	.80	.68
6-13	75	1.90	1.55	1.38	.0110	.0130	.0210	1	.82	.73
6-20	82	1.91	1.61	1.40	.0014	.0085	.0028	1	.84	.73
6-27	89	1.93	1.62	1.41	.0028	.0014	.0014	1	.84	.73
7-5	97	1.98	1.67	1.47	.0062	.0062	.0075	1	.84	.74
7-13	105	2.01	1.74	1.49	.0037	.0087	.0025	1	.87	.74
7-26	118	2.15	1.84	1.67	.0107	.0076	.0138	1	.86	.78
8-11	134	2.40	2.13	2.07	.0156	.0108	.0250	1	.89	.86
8-23	146	2.82	2.62	2.39	.0350	.0408	.0266	1	.93	.85

TABLE 2

Rate of Growth of J. H. Hale Fruits—Season 1921

Date Measured	Days from Bloom	Length	S. Diameter	C. Diameter	Rate of Growth per Day Since Last Measured			Ratio of Three Dimensions		
					L.	S.D.	C.D.	L.	S.D.	C.D.
				FRUIT NO. 1						
5-24	56	1.610	1.27	1.08	.....	.....	.....	1	.79	.67
5-31	63	1.910	1.63	1.47	.0428	.0514	.0557	1	.85	.77
6-7	70	2.080	1.85	1.65	.0242	0314	.0257	1	.89	.79
6-13	76	2.150	1.95	1.77	.0116	.0166	.0200	1	.91	.82
6-20	83	2.220	1.99	1.81	.0100	.0057	.0057	1	.90	.82
6-27	90	2.230	2.03	1.84	.0014	.0057	.0042	1	.91	.83
7-5	98	2.265	2.07	1.89	.0037	.0050	.0062	1	.92	.83
7-13	106	2.269	2.15	1.95	.0005	.0100	.0075	1	.95	.86
7-26	119	2.420	2.39	2.14	.0122	.0184	.0146	1	.99	.88
8-11	135	2.860	2.84	2.69	.0366	.0375	.0458	1	.99	.94
8-23	147	3.08	3.13	3.23	.0093	.0241	.0450	1	1.01	1.04
				FRUIT NO. 2						
5-24	55	1.370	1.17	1.010	.....	.....	.....	1	.85	.71
5-31	62	1.670	1.50	1.360	.0428	.0471	.0500	1	.90	.81
6-7	69	1.830	1.68	1.550	.0228	.0257	.0271	1	.91	.85
6-13	75	1.860	1.76	1.640	.0150	.0133	.0150	1	.95	.88
6-20	82	1.880	1.80	1.650	.0028	.0057	.0014	1	.96	.88
6-27	89	1.930	1.86	1.680	.0071	.0085	.0042	1	.96	.87
7-5	97	1.996	1.90	1.750	.0085	.0050	.0087	1	.95	.88
7-13	105	2.010	1.96	1.810	.0025	.0075	.0075	1	.98	.90
7-26	118	2.110	2.15	2.040	.0076	.0146	.0176	1	1.02	.97
8-11	134	2.535	2.71	2.542	.0265	.0350	.0312	1	1.07	1.00
8-24	147	2.850	3.16	3.060	.0246	.0346	.0398	1	1.11	1.07

TABLE 3

Rate of Growth of Carman—Season 1921

Date Measured	Days from Bloom	Length	S. Diameter	C. Diameter	Rate of Growth per Day			Ratio of Three Dimensions		
					L.	S.D.	C.D.	L.	S.D.	C.D.
					FRUIT No. 1					
4-28	30	0.43	0.31	0.29	.....	.....	.....	1	0.72	0.67
5-9	41	0.71	0.53	0.46	.0254	.0200	.0153	1	0.74	0.65
5-16	48	1.13	0.85	0.73	.0600	.0457	.0385	1	0.75	0.64
5-24	56	1.51	1.22	1.05	.0475	.0462	.0400	1	0.80	0.68
5-31	63	1.72	1.47	1.31	.0300	.0350	.0370	1	0.85	0.76
6-7	70	1.77	1.58	1.44	.0070	.0157	.0180	1	0.89	0.81
6-13	76	1.77	1.67	1.52	.0070	.0150	.0133	1	0.94	0.85
6-20	83	1.79	1.71	1.55	.0028	.0055	.0042	1	0.94	0.87
6-27	90	1.92	1.80	1.65	.0185	.0128	.0142	1	0.93	0.85
7-5	98	2.01	2.02	1.87	.0110	.0275	.0275	1	1.00	0.93
7-13	106	2.35	2.37	2.20	.0425	.0437	.0412	1	1.00	0.94
7-22	115	2.78	2.81	2.63	.0477	.0488	.0477	1	1.01	0.94
					FRUIT No. 2					
4-28	30	0.43	0.29	0.27	.....	.....	.....	1	.67	.62
5-9	41	0.70	0.50	0.43	.024	.019	.014	1	.71	.61
5-16	48	1.01	0.79	0.64	.044	.041	.030	1	.78	.63
5-24	56	1.37	1.14	0.97	.045	.043	.041	1	.83	.70
5-31	63	1.60	1.37	1.22	.032	.032	.022	1	.85	.76
6-7	70	1.68	1.54	1.31	.011	.024	.012	1	.90	.83
6-13	76	1.76	1.57	1.38	.013	.010	.011	1	.89	.78
6-20	83	1.77	1.60	1.46	.001	.004	.011	1	.96	.82
6-27	90	1.84	1.68	1.52	.010	.011	.008	1	.91	.83
7-5	98	2.00	1.87	1.72	.020	.023	.025	1	.93	.86
7-13	106	2.30	2.08	1.96	.037	.026	.030	1	.94	.85
7-22	115	2.53	2.39	2.25	.025	.034	.032	1	.94	.88
					FRUIT No. 3					
4-28	27	0.31	0.25	0.22	.....	.....	.....	1	0.80	0.70
5-9	38	0.53	0.41	0.37	.0200	.0145	.0136	1	0.77	0.69
5-16	45	0.84	0.86	0.58	.0440	.0385	.0385	1	0.80	0.69
5-24	53	1.20	1.06	0.87	.0500	.0470	.0410	1	0.88	0.73
5-31	60	1.47	1.37	1.19	.0385	.0442	.0360	1	0.93	0.81
6-7	67	1.63	1.59	1.39	.0228	.0314	.0285	1	0.97	0.85
6-13	73	1.67	1.67	1.47	.0066	.0133	.0133	1	1.00	0.89
6-20	80	1.68	1.71	1.54	.0016	.0066	.0116	1	1.02	0.92
6-27	87	1.73	1.77	1.61	.0083	.0100	.0116	1	1.02	0.93
7-5	95	1.88	1.95	1.79	.0187	.0225	.0300	1	1.03	0.95
7-13	103	2.06	2.19	2.00	.0225	.0300	.0300	1	1.06	0.97
7-22	112	2.48	2.60	2.47	.0525	.0500	.0522	1	1.04	1.00
					FRUIT No. 4					
4-28	29	0.35	0.27	0.25	.....	....	....	1	0.77	0.71
5-9	40	0.61	0.48	0.41	.023	.019	.014	1	0.79	0.67
5-16	47	0.90	0.75	0.64	.041	.041	.032	1	0.83	0.70
5-24	55	1.29	1.10	0.92	.048	.043	.041	1	0.85	0.71
5-31	62	1.47	1.40	1.15	.030	.042	.032	1	0.95	0.78
6-7	69	1.61	1.50	1.28	.020	.014	.018	1	0.94	0.79
6-13	75	1.63	1.56	1.37	.003	.010	.020	1	0.96	0.84
6-20	82	1.64	1.63	1.45	.001	.010	.011	1	0.99	0.88
6-27	89	1.75	1.69	1.53	.015	.008	.011	1	0.97	0.87
7-5	97	1.90	1.86	1.64	.018	.021	.013	1	1.03	0.95
7-13	105	2.17	2.11	1.90	.033	.031	.032	1	1.06	0.97
7-22	114	2.38	2.45	2.25	.023	.037	.038	1	1.04	1.00

Peach Breeding—Project 4

Technical Phase

C. H. CONNORS

During the season of 1925, a few of the seedlings set in 1921 and 1922 bore fruit.

Of particular interest from the plant-breeding standpoint were 10 self-pollinated seedlings of Eclipse (which is 6714—Belle self-pollinated). Eclipse is a yellow freestone ripening about with Hiley. These seedlings were all yellow, of the same shape as the parent, and of about the same season of ripening, the range being a week before Eclipse to 4 days after. The trees were all similar to the parent. The quality of most of them was about the same as that of the parent. One seedling, practically identical with the parent but ripening one week earlier, was given an introduction number.

This is a good type of segregation for such a genetically heterozygous individual as a peach variety.

Of the others that fruited for the first time, one, of unknown direct parentage, was outstanding. This is an open-pollinated seedling of one of the seedlings resulting from Elberta x Greensboro, The individual was yellow fleshed, of good size and quality, freestone, and ripened about with Carman. If it fulfils its promise, it will be named Golden Jubilee, in honor of that anniversary of the New Jersey State Horticultural Society, which was celebrated at New Brunswick at the ripening period of this fruit.

The breeding work undertaken in the spring of 1926 was somewhat more limited than has been the case for the past few years. Crosses were made on J. H. Hale, as follows:

J. H. Hale x 25416 (ECxA)
J. H. Hale x 32816 (40C-S)
J. H. Hale x 36515 (Primrose)
J. H. Hale x Almond
J. H. Hale x 113115 (B. s-p)
J. H. Hale x Japan Dwarf Blood
J. H. Hale x Goldmine nectarine.

A total of 3,547 blossoms of J. H. Hale were pollinated by hand.

Crosses were made with the expectation of securing a dwarf peach. The seed parent is a semi-dwarf seedling of Elberta self-pollinated. On this were crossed: Double Pink flowered variety, Japan Dwarf Blood, almond. A total of 772 blossoms were pollinated.

There is a decided demand now for varieties ripening one week to three weeks later than Elberta. The difficulty encountered is the lack of a suitable yellow sort for the seed parent. Because of this lack, Iron Mountain, which is very hardy and of good quality, was used this year, and on it were crossed 1515, a late maturing seedling of Elberta; 113115, a seedling of Belle self-pollinated; 13621, a seedling of a seedling of Elberta x Greensboro; 1522, a heterozygous seedling of Elberta x Iron Mountain; a yellow seedling ripening about November 15, secured from D. F. Gaunt, Paulsboro, N. J. A total of 750 pollinations were made on these trees.

Further genetic studies were undertaken in interspecific and interform crosses. Among those attempted were crosses between the peach (*Amygdalus persica*) and the almond (*Amygdalus communis*). This cross has been made elsewhere. The pollen of the almond was furnished by Mr. William Hann, of New Brunswick. Crosses of peach and nectarine were also made, using the Goldmine nectarine, a variety introduced into this country from New Zealand by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, United States Department of Agriculture. On this were crossed almond; 113115, a seedling of Belle, self-pollinated which has scanty pubescence; 6714 (Eclipse); a seedling of Lola, which is almost a nectarine. The number of blossoms pollinated was 1,882. Goldmine was used as pollen parent on J. H. Hale.

The history of fruit varieties is usually hazy. In "Peaches of New York," the statement is made that Elberta and Belle are seedlings of Chinese Cling and the pollen parents are probably Early Crawford and Oldmixon, respectively. To test this, the crosses Chinese Cling with Early Crawford and Chinese Cling with Oldmixon were made this year. The number of blossoms pollinated was 2,629.

The total pollinations made on all trees was 9,580.

Seedlings in the Nursery

As a result of breeding work in 1925, there are now growing in the nursery 1,790 seedlings, as follows:

J. H. Hale x 6714 (Eclipse)	212
J. H. Hale x 91215 (Delicious)	232
J. H. Hale x 25916 (Sunbeam)	240
J. H. Hale x 26616 (Oriole)	237
J. H. Hale x 28216 (Massasoit)	184
J. H. Hale x 30616 (41 S-D)	120
J. H. Hale x 30716 (Rosebud)	186
J. H. Hale x 42216 (Goldfinch)	172
J. H. Hale x Hills Chili	143
J. H. Hale x Amygdalus kansuensis SPI 40001	20
J. H. Hale x Amygdalus kansuensis SPI 39428	5
Chinese Cling x Early Crawford	14
Chinese Cling x Oldmixon	3
Chinese Cling self-pollinated	1
Iron Mountain self-pollinated	6
Iron Mountain x Hills Chili	5
Iron Mountain x 1515 Es-p.	1
Intermediate dwarf Elberta s-p	6
Intermediate dwarf Elberta x Japan Dwarf Blood	3
Total	1790

The Station Collection of Peach Species, Varieties and Types

The horticultural division now has growing upon its grounds at New Brunswick what is regarded as the largest and most complete collection of peach species, varieties, and types to be found anywhere in the world. Larger collections of so-called standard varieties have been assembled in the past and there may be some under cultivation today that exceed the one at New Brunswick. At this station, however, no attempt is being made to assemble merely a great collection of commercial varieties. The plan is to bring together all the species and variations of the peach in order thoroughly to study its characters and to make use of any that may be of value in the breeding work. The New Brunswick collection contains 29 species and types; 41 varieties, mostly introduced from distant countries by the United States Bureau of Plant Industry; 116 standard varieties, 123 selected seedlings from previous breeding work; and other varieties and nectarines, making a total of 334 species, types, and varieties in the collection on July 1, 1926.

In addition, there are growing upon the grounds approximately 3,500 trees from recent breeding work. Some of these have green fruits upon them which will mature this season.

The complete list of the species, varieties and types now being grown follows:

Commercial Varieties of Peaches

Anna
Arp
Augbert
Barbara
Belle
Beers Smock
Ben Munson
Berks Favorite
Bilmeyer
Bowers September
Brackett
Brandywine
Carman
Chairs Choice
Champion
Chinese Cling
Columbia
Connets
Crosby
Dailey
Dewey
Dr. Wooster
Dulce
Early Crawford
Early Elberta
Early Rose
Early Wheeler
Elberta
Estella
Eureka
Fay Elberta
Fitzgerald
Florence
Foster
Fox
Frances
Frank
Frederick
George IV
Gold Drop
Gold Medal
Gordon
Greensboro
Hauss
Heath
Hiley
Hill Chili
Imperial
Ingold
Iron Mountain
Japan Dwarf Blood
Jennie Worthen
J. H. Hale
Kalamazoo
Kathryn
Katie
Krummel
Late Crawford
Late (Rex) Elberta
Leamington
Lemon Cling
Lemon Free
Leona
Liberty
Lizzie
Lockwood
Lola
Longhina
L'Thorn Miller
Lubler
Marquette
Mayflower
McDevitt
Mikado
Miller Late
Morford
Morris White
Mountain Rose
National
Niagara
Oldmixon
Oldmixon Free
Orleans
Palora
Paragon
Peake
Peen-to
Phillips
Ray
Reeves
Roberta
Rochester
Salberta
Salway
Santa Claus
Sellers Orange
Slappey
Sleeper Dwarf
South Haven
Stearn Salway
Stevens
St. John
Strawberry
Stump
Tarbell
Tena
Tennessee Everbearing
Tossetti
Triumph
Tuscan
Valiant
Vanity
Vidette
Wilma
Winter
Woodlawn Golden

Peach Species, Varieties and Types

Introduced by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, United States Department of Agriculture

Amygdalus davidiana		
Amygdalus kansuensis	SPI	39428
Amygdalus kansuensis	SPI	40001
Al (N.Z.)	SPI	43124
Aurora (Chili)	SPI	57688
Bennett's Perfection	SPI	57912
Blood Peach (China)	SPI	36717
Bolivian Clingstone	SPI	36126
Bolivian Cling x Quetta Nect.	SPI	61302
Bresquella (Spain)	SPI	43569
Eagles Beak, seedling of (China)	SPI	43289
Eagles Beak, seedling of (China)	SPI	43290
Fei (China)	SPI	38178
Golden Prolific (N.S.W.)	SPI	57914
Goodman's Choice (N.S.W.)	SPI	55549
Ice Cream (N.Z.)	SPI	43126
Ideal (N.Z.)	SPI	43127
Izquierdo (Spain)	SPI	57686
Izquierdo, Sel. 2 (Chili)	SPI	57687
Late Champion (N.Z.)	SPI	43129
Lippiatt's Late Red (N.Z.)	SPI	43130
Lord Kitchener	SPI	57915
Mexican Peach	SPI	32373
Motion Cling (N.Z.)	SPI	43132
Muir's Perfection (N.Z.)	SPI	43133
Osprey Improved (N.Z.)	SPI	43134
Paragon (N.Z.)	SPI	43135
Pomona Improved (N.S.W.)	SPI	55487
Pomona Majorada (Chili)	SPI	57689
Reina Elena (Chili)	SPI	57690
Rey Alberto (Chili)	SPI	57691
Shalil (China)	SPI	36485
Shipper Cling (N.Z.)	SPI	43136
Sutter Creek (Chico)	SPI	36125
Tardio Amarillo sdlg (Spain)	SPI	55835
Tardio Amarillo sdlg (Spain)	SPI	55836
Transparente (Chili)	SPI	57692
Up-to-date (N.Z.)	SPI	43137
Vainqueur (Spain)	SPI	33219
Watt Early (N.S.W.)	SPI	57917
White Cling (N.S.W.)	SPI	57918
Peach, China	SPI	35201
Peach, China	SPI	43291
Peach, China	SPI	45149
Peach, Dwarf (China)	SPI	41395
Peach (Spain)	SPI	55563
Peach (Spain)	SPI	55564
Peach (Turkestan)	SPI	24807
Peach (Chico, Cal.)	SPI	55813

Nectarines

Commercial Varieties

Bangert (Elberta Seedling)
Hunter
New White
Victory

Introduced by SPI

Ansenne (NZ)	SPI	43139
Crosby	SPI	17777
Diamond Jubilee	SPI	43130
Goldmine	SPI	43141
Lippiatt's Late Orange	SPI	43142
Muir's Seedling (NZ)	SPI	43143
New Boy (NZ)	SPI	43144
Quetta (India)	SPI	34658
Sure Crop (NZ)	SPI	43146
Nectarine (Turkestan)	SPI	26508

Almonds (Amygdalus Communis)

Del Desmayo (Spain)....SPI 33218 Hard shell sweet .

Peach Types, Collected

Albino
Purple Leaf
Purple Stem
Red Stem
Elberta Freak Dwarf
Double flowering, white,
pink
red
Peachmond (Mexico)
Elberta Freak Intermediate

A. platycarpa, Australian saucer peach.

Peach Seedlings at Large

J. Howard Lippincott, early yellow, before Arp
J. Howard Lippincott, white, between Greensboro and Carman
W. I. Coddington
D. H. Tice
Clifford Nevius, Eleanor
James Neilson, late yellow
Mr. Conover

Other Prunus

Prunus armeniaca (apricot)	SPI	17154
Prunus simonii ..:............................	SPI	26886
Prunus domestica x p. spinosa..................	SPI	32670
Prunus serrulata var. sacchaliensis		

Station Seedlings

In this list, the station seedlings, which have been propagated and planted on the horticultural farms, are divided into three groups: 1, those which have been named; 2, those which have appeared promising but which have not been named and introduced; 3, those which have been retained because of some merit which makes them possible breeding materials.

The serial number consists of two parts. The last two digits (as, —14) indicate that the cross was made in 1914. The digits before these two indicate that the order in which the particular seedling was planted in the orchard (as, 6714 was the 67th seedling planted of those bred in 1914.)

The introduction numbers were given arbitrarily, in the order in which the seedlings proved their merit, the letters after the numbers indicating the parentage of that particular individual. For example, the 67th tree in the series bred in 1914 has the serial number 6714. To this was given the introduction number 1*B*, as the first of promise, *B* indicating that it is a seedling of Belle self-pollinated. This was later named Eclipse.

KEY

A. —Arp
B. —Belle
C. —Carman
D. —Dewey
E. —Elberta
E.C.—Early Crawford

Ecl.—Eclipse
G. —Greensboro
L. —Lola
L.C.—Late Crawford
S. —Slappey
S.J. —St. John

s-p or a capital letter alone—Self-pollinated
o-p or 0—Open-pollinated

SEEDLINGS NAMED

Introduction Number	Serial Number	Name
1B	6714	Eclipse
9B.G.—47B.G.	23514	Radiance
22 B.G.	87315	Pioneer
25 B.G.	25614	Cumberland
28 B.E.	36515	Primrose
51 S.A.	25916	Sunbeam
52 S.D.	26616	Oriole
53 L.A.	12516	Marigold
55 L.A.	12916	Buttercup
57 B.	9814	Meteor
58 EG.O.	13421	Golden Jubilee
59 C.S.	30716	Rosebud
60 B.G.	91215	Delicious

PROMISING BUT NOT NAMED

Introduction Number	Serial Number	Introduction Number	Serial Number
2 B.	9914	33 E.B.	32615
4 B.	16614	34 E.	1515
5 B.	16714	35 E.	12515
6 B.G.	19314	36 E.	8415
8 B.E.C.	23114	37 B.G.	23714
10 B.E.	27914	38 E.G.	43215
12 B.E.	29714	39 E.G.	37615
13 B.E.	30314	40 C.S.	32816
14 B.E.	30514	41 S.D.	30616
17 E.B.	37814	42 B.	9414
18 E.	8115	43 E.C.E.	21215
20 E.B.	30315	44 E.B.	30315
23 B.G.	87415	45 E.E.C.	42714
26 B.G.	25714	46 B.	11914
27 B.G.	89015	48 B.	113215
29 E.C.E.	46414	49 B.	92615
30 E.E.C.	21615	50 B.	97815
31 E.C.E.	23515	61 Ecl.	9821
32 E.B.	27415		

RETAINED FOR BREEDING

210	L. o-p	20515	E.C. x E.	63415	E.C. x B.
17914	LC. o-p	21415	E.C. x E.	85615	B. s-p
26214	B. x E.	21815	E.C. x E.	104115	B. s-p
26614	B. x E.	22415	E.C. x E.	105615	B. s-p
37814	E. x B.	22815	E.C. x E.	106815	B. s-p
41514	E. x E.C.	23315	E.C. x E.	107015	B. s-p
43014	E. x E.C.	26015	E.C. x E.	112015	B. s-p
56814	S.J. x E.	27015	E. x B.	112415	B. s-p
2215	E. s-p	27115	E. x B.	113315	B. s-p
3515	E. s-p	28215	E. x B.	114515	B. s-p
4015	E. s-p	29015	E. x B.	13616	L. x A.
6015	E. s-p	29415	E. x B.	22516	L. x S.
6315	E. s-p	31215	E. x B.	27316	S. x D.
7715	E. s-p	33015	E. x B.	27716	EC. x D.
8015	E. s-p	33215	E. x B.	27816	EC. x D.
8115	E. s-p	33315	E. x B.	29616	S. x D.
8915	E. s-p	33815	E. x B.	29816	S. x D.
9915	E. s-p	35215	E. x B.	35816	EC. x A.
12815	E. s-p	35315	E. x B.	40316	S. x A.
14115	E. s-p	35915	B. x E.	4121	SJ. x C. o-p
14315	E. s-p	38815	E. x G.	4521	SJ. x C. o-p
16815	E. x E.C.	38915	E. x G.	9221	Ecl.
19915	E. x E.C.	57415	S.J. x G.	13621	E. x G. o-p

Summary of Varieties, Species and Types of Peaches and Allied Prunus Planted on Horticultural Farms

Farms	Varieties Standard		Varieties Introduced		Seedlings Own		Seedlings at Large		Nectarines		Species and Types Amygdalus		Species and Types Other Prunus	Grand Total
	Pl.	Tw.	Pl.	Tw.	Pl.	Tw.	Pl.	Tw.	Pl.	Tw.	Int.	Col.		
Wolpert Farm Swale	34		2						1		2			40
Spring Triangle					18	8								26
Morrisey Farm	46	4	16	22	47	7		2	6	5	5	8	4	172
Sandfield	46				67	2	2				2	3		121
Gebhardt Farm	25		16		8		3		6		11			69
Totals	150	4	34	22	140	17	5	2	13	5	20	12	4	428
Grand Totals	150		56		157		7		18		32		4	428
Duplications	38		15		34		0		4		3		0	94
Net Totals	116		41		123		7		14		29		4	334

The Self-Fruitfulness of Peach Varieties

Previous reports have shown that the J. H. Hale peach is pollen sterile. Each year this is checked by allowing a branch on a covered tree to self-pollinate. In the season of 1925, 592 blossoms were on the unpollinated branch and 5 fruits set. With the usual run of varieties a good set would have been obtained. The fact that J. H. Hale set 5 fruits indicates that an occasional blossom has a normal development of the pollen grains.

In the spring of 1926, a similar branch was left in J. H. Hale, and of about 500 blossoms, only 7 fruits have set.

In the case of a covered tree of Chinese Cling, 4 fruits are set on a branch which had about 250 blossoms and which was left undisturbed. This is in contrast with the dwarf Elberta seedling, Iron Mountain, and Goldmine—the nectarine—where a full set was obtained upon branches left untouched on trees protected from the visits of insects. A fairly good set was also obtained upon Krummel's October, Late Champion, Lippiatt's Late Red, and Osprey Improved. The latter trees were covered by Mr. Stearns in his peach moth work.

Apple Breeding

In the course in plant breeding, in the College of Agriculture, practical exercises in the breeding of apples were given to the seniors of the class of 1925. As a result of their efforts, the following seedlings are in the nursery:

Williams x Starr	30
Wealthy x Starr	124

In addition to the seedlings, the information that Starr is a compatible pollinator for William and Wealthy is of interest.

Carnation Breeding—Project 9

C. H. Connors

During the season of 1925 to 1926, the scarlet seedling named *Rutgers* in the spring of 1925 was given a further trial and some few plants were disseminated. Further distribution will be made next year.

Of the two medium pink seedlings, No. 510 L has been selected as the better, and will be tested for one more year before being named and disseminated.

The pure line work was temporarily discontinued, but the pure single flowered seedlings in white, light pink, dark pink, scarlet, and purple have been retained for a propitious time.

Breeding work during this season was devoted to yellows, to improving further the scarlets and deep pinks. Laddie and a red sport of Laddie were used, together with our own seedlings.

The variety Laddie has many desirable characters. Although slow in coming into bloom, and not a free producer, the stiff long stem, the large size of the flower, and the splendid keeping qualities of the flower make it desirable as a commercial sort. Unfortunately, from a breeding standpoint, it is sterile as a male and is inclined to phyllody of the ovules. Occasionally, however, a few seeds are produced, so that by using Laddie as a seed parent, it may be possible to secure seedlings with some of its desirable characters.

Other Dianthus

The collection of Dianthus species and types has been increased to 40 by accessions from various botanical gardens throughout the world and by purchase.

Hydrangea Culture—Project 12

Charles H. Connors

The experimental work with hydrangeas continues, in an endeavor to solve some of the problems of color control and to arrive at the underlying cause.

In the first instance, the available material which seems adapted to secure the acid reaction necessary for the production of blue flowers—aluminum sulfate—is not safe for blanket recommendations. In trials in the usual procedure of handling this plant, it has been found that unless the plant is potted, from the field, a sufficient length of time to develop a full root system, the production of blues is uncertain. This applies to larger plants in 6- or 8-inch pots. It may be necessary, therefore, to recommend that the fields in which the hydrangea plants are grown in the summer be treated to adjust the reaction.

During the past season, 18 percolators were used for growing hydrangeas with constant drip. The solutions used were Tottingham solutions as modified by Jones and Shive and further modified to secure variable hydrogen-ion concentration, by the use of varying amounts of di-basic and mono-basic potassium phosphate, as suggested, in person, by Dr. J. W. Shive.

Three reactions were used, having hydrogen-ion concentrations at about 5.5, 6.0, 6.5, which in soils would give blue flowers, intermediate colored flowers, and pink flowers respectively. Each of these was used with ferric iron in the form of the soluble phosphate, ferrous iron in the form of ferrous sulfate, and without iron. No chlorosis appeared in the solution lacking iron.

The plants used were out of 2½-inch pots, the soil being prepared to produce pink flowers. All of the plants when grown in cultures bloomed pink, thus verifying previous findings that the color of hydrangea flowers is influenced by the reaction of the soil in which the roots are growing at the time the flower buds are formed.

The Culture of Perennials—Project 22

CHARLES H. CONNORS

Iris Rhizome Rot

The iris rhizome rot, *Bacillus cartovorus,* L. R. Jones, causes, at times, considerable losses in iris plantings. In an endeavor to control this, a variety—Purple King— that was badly diseased was selected.

The divisions were made as uniform as possible. Part of them were scraped clean of the disease and part were left undisturbed. There were then immersed in the following germicidal and fungicidal solutions: Corrosive sublimate, formaldehyde, copper sulfate, bordeaux 4-4-50, bordeaux, 2-4-50, Semesan. Part of the divisions were not treated.

These were planted in the usual manner in the first week of July, 1924. After two years, no rot has appeared on any of the treatments or on the control.

It is obvious that this common soil organism is somewhat variable in its virulence with variations in climatic and other environmental conditions.

Culture of Dahlias

During the season of 1925, 428 varieties of dahlias were grown under test.

In the seedling test garden operated in conjunction with the Dahlia Society of New Jersey, 82 seedlings were under trial and 28 certificates were awarded to seedling varieties which scored 85 points or more.

The fertilizer test was devoted to the effect of potash upon root production. The variety used—Lady Helen—is a notoriously poor root producer. In the soil in which these plants were grown, no difference in weight of tuberous roots produced upon no potash, 150 pounds to the acre, and 300 pounds to the acre, was noticed. The season was exceptionally dry, which may have had some effect.

One limiting factor in dahlia growing is the damage done very early in the season by thrips—the leaves are crippled and the plants become stunted. It was found that 1½ or 2 per cent nicotine dusts, if applied twice a week for the first two weeks after planting and once a week for the next two weeks apparently controlled this insect.

REPORT OF THE DEPARTMENT OF POMOLOGY

ARTHUR J. FARLEY AND J. HAROLD CLARK

The department of pomology has conducted experimental work during the past year along the following lines: Spraying of apples and peaches, fertilization of apples, pollination of apples, cultural studies with grapes and strawberries, and variety tests including tree fruits, small fruits, and grapes.

Spraying Experiments With Peaches

Spraying experiments with peaches were conducted at the Horticultural Farm, New Brunswick, and at the Del Bay Farms, Bridgeton.

Horticultural Farm, New Brunswick

The two chief objects of the New Brunswick experiment were: first, to determine the value of finely ground peat and gypsum as preventives of arsenical injury when used as substitutes for hydrated lime in Dry Mix applied to peach trees in combination with lead arsenate; and second, to compare the effect of hydrated lime and freshly slaked lime on arsenical injury when used in preparing Dry Mix applied in combination with lead arsenate.

The following mixtures were applied to Elberta trees planted in 1918:

1—Check.
2—Sulfur 8 pounds, ground peat 4 pounds, powdered lead arsenate 1 pound.
3—Sulfur 8 pounds, ground peat 4 pounds, powdered lead arsenate 2 pounds.
4—Sulfur 8 pounds, hydrated lime 4 pounds, powdered lead arsenate 2 pounds.
5—Sulfur 8 pounds, hydrated lime 4 pounds, powdered lead arsenate 1 pound.
6—Sulfur 8 pounds, stone lime 4 pounds, powdered lead arsenate 1 pound.
7—Sulfur 8 pounds, gypsum 4 pounds, powdered lead arsenate 2 pounds.

Lead arsenate was used in two applications; first when the shucks started to split on May 13 and again on May 26. On June 2, slight foliage injury was noticed on all sprayed trees, but there was no defoliation at this time. On June 17, a slight reddening appeared at the base of the new growth and on the twenty-second, cankers were found developing on the one-year wood, together with considerable leaf drop. The affected leaves were yellow, many having no external indication of injury. The cankers consisted of a light, brownish, purple area around the base of the buds and new shoots. The bark in most cases was not sunken at this time. The injury was most severe on the trees reeciving treatments 2, 3, and 4. All other treatments showed very slight injury, both from the standpoint of leaves and twigs, except 8, which showed cankering similar to other treatments, including 2 pounds of lead arsenate, but developed practically no leaf injury. Starting with the check or unsprayed trees the treatments were ranked in the following order on June 22 on the basis of cankering of one-year wood.

1—No cankers.
6 and 7—Slight cankering.
2, 5 and 8—Severe cankering.
3 and 4—Very severe cankering.

Defoliation was most severe under treatments 3 and 4, while the cankers continued to increase in size and number for several weeks. The gumming of some of the cankers on the one-year wood was first noticed about July 1. The conditions described are typical of those generally referred to as arsenical injury. Therefore, it seems reasonable to assume that gypsum and peat are both ineffective substitutes for hydrated lime for use in connection with the preparation of Dry Mix. On the other hand, 4 pounds of freshly slaked stone lime appears to be more effective than the same amount of hydrated lime as a preventive of arsenical injury. This is probably due to the increased amount of calcium hydroxide, together with a minimum amount of calcium carbonate. It is, at least, further evidence that it is desirable to increase the lime content of Standard Dry Mix (8-4-50 formula) when used in combination with lead arsenate. This question will require further study in order to develop a spray mixture for peaches that will be just as effective as New Jersey Dry Mix, and safer to use on peaches in combination with lead arsenate.

Del Bay Farms, Bridgeton

A spraying experiment was carried on at the Del Bay Farms, Bridgeton, with the following objects:

1—To test colloidal sulfur with and without the addition of lime in applications containing lead arsenate.
2—To compare the effectiveness and safety of Dry Mix made with varying amounts of sulfur and lime.
3—To compare the effectiveness of superfine dusting sulfur and commercial sulfur when used in preparing Dry Mix.

The following mixtures were applied in a 12-year old orchard containing the varieties Carman, Lola, Hiley, Belle, Elberta, and Iron Mountain.

1—Colloidal sulfur 4 pounds to 50 gallons water plus lead arsenate 1 pound to 50 in shuck fall and following applications.
2—Same as 1 plus 4 pounds hydrated lime to 50 gallons spray mixture in applications containing lead arsenate.
3—Dry Mix 2-4-50 with lead arsenate in first 2 applications.
4—Standard Dry Mix with lead arsenate in first 2 applications.
5—Eight pounds Standard Dry Mix to 50 gallons water with lead arsenate in first 2 applications: Sulfur 5.12 pounds, Lime 2.56 pounds, Kayso .32 pound.
6—5-4-50 Dry Mix made from Superfine Dusting Sulfur.
7—5-4-50 Dry Mix made from Commercial Sulfur Flour.
8—Standard Dry Mix with lead arsenate in first 2 applications followed by 8 pounds sulfur and ½ pound Kayso to 50 gallons in later applications.
9—Sulfur 8 pounds, Kayso ½ pound, water 50 gallons plus lead arsenate in first 2 applications.
10—Self-boiled lime-sulfur with lead arsenate in first 2 applications.
11—8-8-50 Dry Mix with lead arsenate in first 2 applications.
12—Check.

Applications were made in accordance with the Experiment Station spray calendar, the shuck split spray being applied on May 1.

Scab and brown rot control was very satisfactory under all treatments, the amount of disease not being sufficient to make a detailed count of affected fruit practicable. Furthermore, the amount of arsenical injury was negligible with the exception of treatments 1 and 9, where no lime was used in applications containing lead arsenate. These two treatments caused considerable leaf injury, including slight defoliation, together with cankering of the one-year wood. All treatments, except 10 and 11, caused a moderate amount of arsenical injury in the form of cankering and slight leaf injury, thus indicating again the importance of using plenty of lime in combination with lead arsenate or sulfur-lead arsenate mixtures applied to peach foliage.

Apple Pollination Studies

The question of pollination in relation to fruit set of apples constitutes a problem of increasing importance in the commercial apple growing sections of the state, where there is a tendency to plant relatively large blocks of one variety. This problem is being studied quite thoroughly by a number of state agricultural experiment stations with rather conflicting results. Furthermore, it is quite apparent that local conditions have a direct effect upon results, thus making it desirable to duplicate to some extent pollination studies carried on in other states under somewhat different conditions. It is also true that some of the varieties that are of commercial importance in New Jersey are not included among those studied by other investigators.

In view of this increasing need for more definite information based on New Jersey conditions, some apple pollination studies were started during the spring of 1926. It was decided to limit the work the first year to a study of some of the varieties that might be used as pollinizers for Stayman. Two Stayman trees were enclosed in a cheesecloth tent just previous to blossoming. One tree was in the variety orchard at the Horticultural Farm, New Brunswick, and the other was in the L. T. Hallock orchard near Clayton. Both trees were of approximately the same size, the tree in the Horticultural Farm orchard being 10 years old and the tree in the Hallock orchard 12 years old. The Horticultural Farm tree was in a moderately vigorous condition, whereas the Hallock tree was somewhat lacking in vigor because of insufficient nitrogen and moisture. Both trees had a set of fruit buds and were full of bloom. Ideal conditions for pollination prevailed throughout the blossoming period in both orchards from the standpoint of temperatures and wind. It was unusually dry, however, a condition that may have affected pollination to some extent.

It was assumed that Stayman is entirely self-sterile and for that reason the blossom buds were not emasculated before applying the pollen, which was collected in small tubes and applied with camel's hair brushes. Pollen from the following varieties was used in pollinating the Stayman tree at New Brunswick: Baldwin, Delicious, Golden Delicious, Gravenstein, Grimes, Jonathan, McIntosh, Melba, Rome, Smokehouse, Starking, Starr, Stayman, and Wealthy. The Stayman tree in the Hallock orchard was pollinated with pollen from the following varieties: Delicious, Golden Delicious, Grimes, Jonathan, McIntosh, Melba, Smokehouse, Starking, Starr, Stayman, and York.

There was practically no set of fruit on the hand pollinated tree in the Hallock orchard, practically all of the fruit dropping within two weeks of petal fall. The fruit set was also very light on the open pollinated Stayman trees in this orchard, notwithstanding a heavy bloom, plenty of bees, and ideal weather conditions for pollination. It is quite evident that the light set of fruit was due to improper nutrition rather than to the failure of the blossoms to become pollinated, since pollen that was very effective at New Brunswick failed to give results in the Hallock orchard.

TABLE 1

Number of Blossoms Pollinated and Number of Fruits Set July 1 on Stayman Tree at New Brunswick

Variety of Pollen	Number of Blossoms Pollinated	Number of Fruit Set	Per cent of Fruit Set
Baldwin	366	0	0
Delicious	392	67	17.09
Golden Delicious	270	36	13.33
Gravenstein	447	1	0.22
Grimes	138	14	10.14
Jonathan	345	69	20.00
McIntosh	697	108	15.49
Melba	506	64	12.64
Rome	916	112	12.22
Smokehouse	522	7	1.34
Starking	770	61	7.92
Starr	859	91	10.59
Stayman (self pollinated)	545	5	0.91
Wealthy	365	45	12.32
Check (unpollinated)	611	0	0
Stayman—open pollinated ... Vigorous tree, outside branch	217	47	21.65
Stayman—open pollinated ... Vigorous tree, low shaded branch	199	35	17.58
Stayman—open pollinated ... Weak tree	524	45	8.58

Table 1 shows the number of blossoms of each variety pollinated and the number of fruits set at New Brunswick, while table 2 shows the percentage of blossoming clusters having one or more fruits on July 1.

The fruit set on July 1 is not an absolutely correct indication of the effectiveness of the different kinds of pollen, since some blossoms set fruit that fell off before July 1, because of lack of sufficient nutrition in individual spurs or twigs. However, the percentage of drop before July 1 was practically the same for all varieties, thereby making the record on that date a satisfactory indicator of the relative value of the various varieties as pollinizers for Stayman.

TABLE 2

Percentage of Blossoming Clusters of Stayman With One or More Fruits on July 1

Hand Pollinated Tree

Variety of Pollen	Clusters With Fruit	Variety of Pollen	Clusters With Fruit
	per cent	*per cent*	*per cent*
Baldwin	0	Melba	40.00
Delicious	72.00	Rome	44.00
Golden Delicious	40.00	Smokehouse	18.51
Gravenstein	2.00	Starking	50.00
Grimes	32.25	Starr	52.00
Jonathan	74.00	Stayman	4.00
McIntosh	60.00	Wealthy	48.00

Open Pollinated Trees

Weak tree	34.88
Vigorous tree, outside branch	92.00
Vigorous tree, low shaded branch	62.00

All of the varieties used as pollinizers at New Brunswick were quite satisfactory with the exception of Baldwin, Gravenstein, and Smokehouse. Jonathan, Delicious, and McIntosh pollen gave the heaviest set of fruit, with Golden Delicious, Melba, Wealthy, Rome, Starr, and Grimes close seconds. Starking does not show up very well in comparison with Delicious on the basis of actual percentage of blossoms setting fruit, but looks better when the comparison is made on the basis of the percentage of blossoming clusters having one or more fruits on July 1. There appears to be almost as much variation in fruit set between clusters of bloom, individual branches, or even entire trees of one variety as there is between trees of different varieties. Furthermore, the percentage of fruit set as a result of hand pollination by the methods used in this experiment is considerably lower than the average set on vigorous, open pollinated trees in the Horticultural Farm orchard and higher than weak trees that are open pollinated.

It is a well-known fact that bees visit the same blossom more than once, thereby making it desirable to make more than one application of pollen by hand in order to have the results compare favorably with nature's method. Furthermore, we know that some spurs and flower clusters are more vigorous than others, and for that reason better able to hold a given amount of fruit for a longer period. On the other hand, a larger percentage of fruits dwarfed by aphis remain on a given spur than would be the case if the fruit developed to a normal size. This again is associated with the nutritive condition of the spur or flower cluster rather than with pollination of the blossoms. It is, therefeore, very important that pollination studies involving comparisons between varieties be conducted on trees or branches of uniform vigor.

Cultural Studies of Strawberries

Many strawberry growers in the central and southern parts of the state have difficulty in securing a satisfactory stand of runner plants in connection with the development of the common matted row. Some growers believe the difficulty is due to a disease prevalent in locally grown plants, and, therefore, have tried plants purchased from nurserymen or growers in other strawberry growing districts. The results in most cases have not been satisfactory. It is also thought that the time of setting the parent plants might have some influence on the development of the runner plants. In order to secure some data and make observations relative to the effect of source of plants and time of planting on the development of the matted row, a field test was started during the spring of 1926 in cooperation with Mr. Aaron Collins, of Moorestown. For the source of plant study, approximately 300 plants of Howard 17 were secured from four sources and planted in adjoining rows in a field set aside by Mr. Collins for the cooperative experimental strawberry project. Two rows of plants from each source were planted about 18 inches apart in rows 4½ feet apart. Plants were secured from the Horticultural Farm, New Brunswick; the W. F. Allen Company, Salisbury, Maryland; Levi Walton, Moorestown; and Aaron Collins, Moorestown. The Horticultural Farm plants were somewhat larger than the others, both from the standpoint of crowns and the root systems. The Allen plants were of average size and quite uniform. The Levi Walton plants were taken from a field where great difficulty had been experienced the previous summer, and where the stand of plants was very poor. The plants supplied by Mr. Collins were probably somewhat above the average used by commercial strawberry growers in the Moorestown district. All of the plants in this particular test were set on April 1.

In addition to the plants set on April 1, two later plantings of the Horticultural Farm and the Aaron Collins plants were made, one on April 13, and the other on April 26, in order to study the effect of time of planting.

Rather marked differences were noticeable in the various lots of plants as soon as they started to grow. On June 17, the plants in each row were classified as very vigorous, vigorous, weak, very weak, and dead, with the results shown in table 3.

TABLE 3

Relative Vigor of Strawberry Plants on June 17—Experimental Plot, Aaron Collins, Moorestown

Source of Plants	Date of Planting	Very Vigorous	Vigorous	Weak	Very Weak	Dead
		per cent	*per cent*	*per cent*	*per cent*	*per cent*
Collins	April 1	23	44	28	3	2
Allen	April 1	14	38	38	7	3
Walton	April 1	3	16	31	13	37
New Brunswick ..	April 1	75	22	3	—	—
New Brunswick ..	April 13	13	48	36	3	—
Collins	April 13	—	29	57	7	7
Collins	April 26	—	23	52	8	17
New Brunswick ..	April 26	34	58	8	—	—

The various grades of plants in table 3 could be described as follows on June 17:

Very vigorous: Three crowns, 12 to 15, leaves fully developed, 6 to 8 runners, most of which have leaves of first runner plant just developing.

Vigorous: Two crowns, 8 or 9 leaves fully developed, not over two runners.

Weak: One crown, 3 or 4 leaves fully developed, no runners.

Very weak: One crown, 1 or 2 leaves or old plants with a relatively large number of very small leaves, no runners.

The greatest leaf spread on the various grades of plants was as follows:

Very vigorous—6¼ inch; vigorous—5⅛ inch; weak—4¼ inch; very weak —2¼ inch.

The very vigorous plants on June 29 had an average of 3 rooted runners per plant, together with 5 or 6 more almost rooted. The weak plants on the other hand averaged less than 1 rooted runner per plant. Further observations will be made and data secured from time to time throughout the season, followed by some comparative crop records next spring.

Observations on the Fruit Bearing Habit of Wealthy, McIntosh and Baldwin, Horticultural Farm, New Brunswick, New Jersey, 1925

It is a well-known fact that the apple tree bears its fruit terminally on spurs, laterally on one-year wood, and terminally on one-year wood, frequently referred to as spur, axillary, and terminal fruits. Rome usually bears most of its crop terminally and laterally on one-year growths, some of which might be classed as long spurs. McIntosh, on the other hand, seldom produces fruit terminally on one-year wood, but bears largely on short spurs. In other words, the fruiting habit of the apple varies with the variety. Furthermore, the fruiting habit of the same variety may vary under different conditions affecting the growth of the tree. For example, the Baldwin may under certain conditions produce the majority of its fruit on spurs and under other conditions produce a large amount of fruit terminally on rather long growths of one-year wood. The proportion of spur, axillary, and terminal fruits also varies with the age of the tree, since this is one of the factors that influences vigor and growth. The following records on the fruit-bearing habit of Wealthy, McIntosh, and Baldwin secured in the variety orchards at New Brunswick during the season of 1925 are of interest. In recording these yields all fruits produced terminally on 1924 growths over 2½ inches long, were classed as terminal fruits, and all fruits produced terminally on 1924 growths 2½ inches long or less, were classed as spur fruits. Axillary fruits are those produced laterally on one-year wood.

TABLE 4

Number and Percentage of Spur, Axillary, and Terminal Fruits on Wealthy, McIntosh, and Baldwin Variety Orchards, New Brunswick, 1925

	Spur Fruits		Axillary Fruits		Terminal Fruits		Totals
	No.	Pct.	No.	Pct.	No.	Pct.	No.
13-year Wealthy ...	1005	58.16	110	6.36	613	35.47	1728
9-year Wealthy ...	227	24.21	306	26.75	561	49.04	1144
9-year McIntosh ..	922	92.20	78	7.80	...	....	1000
9-year Baldwin ...	459	20.60	101	4.60	1661	74.70	2221

A study of table 4 brings out several points of general interest. One striking condition is the difference in the bearing habit between the 13-year-old and the 9-year-old Wealthy On the 13-year-old tree almost 60 per cent of the fruits were produced on spurs, whereas on the younger tree slightly less than 25 per cent were in this class. Furthermore, nearly 50 per cent of the fruits on the 9-year-old tree were classed as terminals, whereas only 35 per cent of the fruits were in this class on the 13-year-old tree. The relative percentage of axillary fruits produced by the two trees is also striking, with only 6 per cent on the 13-year-old tree, and almost 27 per cent on the 9-year-old tree. It is also of interest to know in this connection that the 13-year-old tree has developed the biennial bearing habit to a marked degree, while the younger tree is bearing annually as indicated by the following yields, the figures representing 16-quart baskets:

1923	6.25 baskets
1924	10.50 baskets
1925	15.25 baskets

It is, of course, impossible to draw any definite conclusions from these figures relative to biennial bearing, but they clearly indicate the difference in fruiting habit existing between trees of the same variety that vary in age, vigor, and general condition.

TABLE 5

Relative Size of Spur, Axillary and Terminal Fruits on Wealthy and Baldwin Variety Orchards, New Brunswick, 1925

Total yield 8 bushels	Total fruits			2¾ and up		2½ to 2¾		2¼ to 2½		Less than 2¼	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Spur	1005			32	3.18	504	50.15	357	35.52	112	11.14
13-year Wealthy											
Axillary	110			—	—	20	18.18	47	42.73	43	39.09
Terminal	613			5	0.81	189	30.85	276	45.02	143	23.33
Total yield 7½ bushels	1728	3 to 3¼		2¾ to 3		2½ to 2¾		2¼ to 2½		Less than 2¼	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Spur	277	19	6.86	91	32.85	143	51.62	24	8.66	—	—
9-year Wealthy											
Axillary	306	—	—	32	10.46	188	61.44	80	26.14	6	1.96
Terminal	561	32	5.70	155	27.41	316	56.33	53	9.44	5	0.89
Total yield 16½ bushels	1144	3 and up		2¾ to 3		2½ to 2¾		2½ or less			
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent		
Spur	459	157	34.2	188	40.9	91	19.8	23	5.0		
Baldwin—											
Axillary	101	13	12.8	31	30.7	42	41.6	15	14.8		
Terminal	1661	427	25.7	642	38.6	417	25.0	175	10.5		
	2221										

The contrast in bearing habit between Baldwin and McIntosh is also very striking with nearly 75 per cent terminal fruits on Baldwin as compared to none on McIntosh. The record on Baldwin is particularly interesting, since it is a variety that is often referred to as never producing many terminal fruits. Furthermore, it is evident that terminal fruits other than those produced on spurs sometimes produce a heavy crop, since in this particular case a 9-year-old Baldwin tree bearing 16½ bushels of fruit produced only 20 per cent of the crop on spurs. However, the effect of this heavy yield on the following year's crop was the same as a similar yield on spurs, since the 1926 crop on this particular Baldwin tree is very light.

Relative Size of Terminal, Axillary, and Spur Fruits

In addition to the number of fruits, the relative size of the spur, axillary, and terminal fruits produced by these trees was determined by running each lot separately over a Cutler grader. The results are shown in table 5.

The data in table 5 indicate that on these trees the spur fruits average the largest, the terminal fruit next and the axillary fruits the smallest. This fact combined with the relatively small percentage of axillary fruits indicates that such fruits cannot be depended upon to any great extent to produce a marketable crop. The terminal fruits on the other hand, although not quite so large, compare favorably with those produced on spurs. The slightly smaller average size of the terminal fruits in comparison with the spur fruits is probably due to the fact that each bearing terminal produced an average of 4 or 5 fruits, while the average number of fruits on spurs was between 2 and 3. It is also true that axillary fruits produced on younger, more vigorous trees would be larger than indicated in table 5 and, therefore, worth more on the market.

Rate of Growth of Apple Fruits

J. H. CLARK

The usual method of measuring the size of an apple is by its transverse or cheek to cheek diameter. For commercial purposes this is perhaps satisfactory enough, although with very oblate or very conic apples the one diameter measurement does not give an accurate idea of the cubical contents or actual size of the fruit.

The transverse diameter has often been the only one considered by investigators studying fruit growth. This has been true in connection with studies of rate of apple growth made at this Station.[1] However, in this connection it would seem advisable to make a more complete size record, especially if the rate of increase of one diameter of the fruit might be greater than the rate of increase of another diameter. In order to determine whether such a difference in rate of growth of different diameters may occur, and to secure further data on the rate of growth of apple fruits, a series of measurements was made on Stayman apples during the summer of 1925. Measurements were made at approximately weekly intervals of the greatest transverse or cheek diameter and the greatest vertical diameter. In measuring the vertical diameter, one member of the calipers was placed across the cavity, adjacent to the stem while the other member was placed on the highest point of the apex. Thirty apples on each of four 9-year-old trees were included in the test. Representative fruits were selected in such a way that an equal number, six each per tree, came from terminal buds, axillary buds, 1-year-old spurs, old spurs exposed to full sunlight, and old spurs near the center of the tree.

---

[1] Farley, A. J. 1924 Report of Department of Pomology. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1923:106.

On July 6 the average vertical diameter of all fruits was 1.284 inches and the average transverse diameter, 1.558 inches. On October 6, the average vertical diameter was 2.095 inches and the average transverse diameter 2.593 inches. a gain of 0.811 inches and 1.035 inches respectively. The ratio of vertical to transverse diameter on July 6 was 1:1.21 and on October 6 was 1:1.24. This shows that with this particular variety the fruit tends to become slightly more oblate as the season progresses and the actual volume of the fruit does not increase quite so rapidly as does the cheek to cheek diameter.

Since the measurements were made of fruits from terminal buds, axillary buds, and different types of spurs, an opportunity was offered of comparing the rate of growth of fruit produced on these various types of growth. On July 6, the average size of fruits growing on the five different producing areas included in the experiment was about equal, except that the fruit from axillary buds was a little smaller than fruit from the other four groups. By October 6, the axillary fruits were still smaller than the others, although they had made more of a gain than the fruits on old spurs near the centers of the trees. Table 1 gives the average gains in inches in size of the various groups of fruit during the period July 6 to October 6.

TABLE 1

Average Gains in Size of Various Groups of Apples From July 6 to October 6

	Terminal	Axillary	New Spurs	Old Spurs Exposed	Old Spurs Inside Trees	Average
Number of fruits measured..	24	24	24	24	24	
Gain in transverse diameter	1.08	1.00	1.05	1.06	.96	1.035
Gain in vertical diameter ...	0.81	0.80	0.80	0.84	.78	0.811
Difference	0.27	0.20	0.25	0.22	.18	0.224

Since the ratio of transverse diameter gain to vertical diameter gain is greater in the case of fruits borne terminally than in any other group, these terminal fruits apparently flattened out more than the others. Fruits on spurs near the center of the tree not only made slower gains during the latter part of the growing season, but also tended to remain more conical or less oblate than any other class.

Comparative Yield of Several Standard Varieties of Apples—Horticultural Farm Orchard, New Brunswick

The age at which an apple tree may be expected to produce profitable crops of fruit is a question in which every fruit grower is interested. Furthermore, the comparative productiveness of standard varieties of apples during the first few years of bearing and what is considered a fair crop for a 7-, 8-, or 9-year-old apple tree are questions of interest in connection with the development of an orchard. The figures in table 1 based upon a careful record of yields during 1923, 1924, and 1925 in one of the variety orchards on the Horticultural Farm planted in 1916 form a basis on which to judge the normal productiveness of young apple trees. These yields are not given as a maximum or a minimum to be expected from a young orchard, but simply show what actually happened in one orchard containing trees of average size and vigor.

TABLE 1

Yields From an Apple Orchard Planted in 1916—*Horticultural Farm, New Brunswick, N. J.*

All Yields are Given in Terms of 16-Quart Baskets

Variety	1923			1924			1925			Average total yield per tree for 3 years
	Highest yielding tree	Lowest yielding tree	Average yield per tree	Highest yielding tree	Lowest yielding tree	Average yield per tree	Highest yielding tree	Lowest yielding tree	Average yield per tree	
Baldwin	13.0	2.0	7.5	7.8	1.3	6.4	40.0	13.5	24.8	38.7
Delicious	15.0	5.3	8.8	6.3	0.3	2.6	26.0	13.5	18.9	30.3
Gravenstein	19.0	2.0	7.3	21.8	0.5	10.0	54.0	5.0	21.2	38.5
Grimes	16.0	1.0	7.9	8.0	0.5	3.0	29.5	2.0	16.1	27.0
McIntosh	9.8	0.8	3.1	29.5	0.5	14.4	19.3	3.5	11.4	28.9
Paragon	9.8	3.0	5.0	21.0	10.0	14.8	30.0	12.0	18.5	38.3
Stayman	16.5	1.8	10.7	18.0	4.5	10.0	31.0	9.3	17.1	37.8
Wealthy	7.5	1.5	4.3	16.8	4.0	10.5	16.8	6.8	11.7	26.5
Williams	3.5	0.5	1.9	6.5	2.0	5.5	17.3	5.3	11.0	18.4
Wagener	7.0	2.0	3.6	7.3	0.5	3.0	13.3	1.0	6.5	13.1

These figures show what every grower has observed in his own orchard relative to the early bearing age of Stayman. Unfortunately, the yields in 1920, 1921, and 1922 were not recorded, since Stayman and Wealthy were the only varieties that produced anything like a crop before 1923. Baldwin and Gravenstein, generally considered slow in coming into bearing, compare very favorably with Stayman and Paragon in this orchard on the basis of the three crops recorded. This condition is due in a large measure to the heavy crop produced by these two varieties in 1925, although the earlier yields are also higher than are generally expected from such varieties. Furthermore, the high average for Gravenstein is partly due to the highest yielding tree in 1925 with a crop of 54 sixteen-quart baskets or 27 bushels on a 9-year-old tree. This particular tree is growing under very favorable conditions from the standpoint of soil and moisture, and at the close of the season in 1925 had a maximum width of 30 feet and a maximum height of 19 feet. The total three-year production for this particular Gravenstein tree is over 37 bushels as compared to 13½ bushels, the average three-year production per tree for 10 other Gravenstein trees in the same orchard, or 19 bushels when the highest yielding tree is included in the average.

Delicious, McIntosh, Grimes, and Wealthy have produced approximately the same amount of fruit during the three-year period, the average for the four varieties being approximately 28 sixteen-quart baskets, or 14 bushels per tree. Delicious is generally slower than McIntosh in coming into bearing, but in this orchard it is ahead in spite of a very small crop in 1924. The McIntosh yield has been somewhat lower than was expected, but these trees are now the largest in the orchard and should yield heavily during the next three-year period.

Williams runs true to form with a slow start and a very low average yield, per tree until 1925 when it produced a crop equal to McIntosh and Wealthy. Wagener is the lowest yielding variety in the orchard, primarily because of the small size of the trees. Two Wilson Red June trees in this orchard were top-worked to Golden Delicious in 1921. One of these top-worked trees produced 7 and the other 10 sixteen-quart baskets of fruit in 1925, which is just one more example of the early age at which this variety bears profitably.

Propagation and Distribution of Peach Seedlings

Approximately 10.000 seedlings were budded to 20 different varieties during the summer of 1925. The following station and special varieties were propagated:

2026	Primrose	1855	58 EG-O
620	Rosebud	550	Radiance
545	Eclipse	304	Pioneer
292	Massasoit	256	Delicious
255	Marigold	259	Meteor
237	Buttercup	363	Oriole
125	P. Davidiana	445	Cumberland
521	61 ECL	96	Goldmine Nectarine
50	J. H. Hale	50	Wilma
50	Roberta	50	Salberta

Unfavorable conditions for budding, due primarily to dry weather, resulted in the poorest bud take experienced since the peach seedling propagation work was started on a commercial scale. In view of this condition, the number of trees available for distribution in the fall of 1926 will be very small in comparison with the number budded.

During the fall of 1925 and the spring of 1926 over 7,000 trees of 15 varieties were distributed among 172 growers of the state. A large majority of these trees were distributed among residents of New Jersey, but the distribution also included 25 growers and agricultural experiment stations in 16 other states and 2 foreign countries; namely, Canada and New Zealand.

Thirty-three collections of 25 trees each were sent to members of organized boys' fruit clubs in Salem, Middlesex, Burlington, Cumberland and Mercer counties.

The following varieties were distributed:

Recommended for commercial planting: Pioneer (22 BG), Cumberland (25 BG), Radiance (47 BG), Eclipse (1 B), Primrose (28 BE).

Varieties for roadside or local markets: Rosebud (59 CS), Oriole (52 SD), Delicious (60 BG).

Home orchard varieties: Buttercup (55 LA), Marigold (53 LA), Sunbeam (51 SA), Massasoit (56 SD), Meteor (57 B).

Brief descriptions of all of the above varieties with the exception of Pioneer will be found in the 1924 report,[1] and Pioneer is described in the 1922 report.[2]

Three varieties; namely, Cumberland, Radiance, and Eclipse were released to New Jersey nurserymen during the year, a total of 30,000 buds being sent out for propagation purposes. Eight test orchards have now been established in different sections of the state, several of which produced fruit during the past year. These orchards are located as follows:

P. E. Van Riper, Allendale.
Arthur J. Farley, Middletown.
Locust Grove Farm, Westville.
John Casazza, Vineland.
John H. Hankinson, Pennington.
Lester Collins, Moorestown.
W. H. Parkhurst, Hammonton.
Del Bay Farms, Bridgeton.

Variety Orchards

The variety problem is one of perennial interest to fruit growers. The identification of specimens of old varieties and the recommendation of new varieties for planting are two types of service offered by the Experiment Station. This service necessitates a rather large variety orchard. At present the variety orchards include 154 varieties of apples and crabapples, 334 species, types and varieties of peaches, 60 pears, 39 plums, 67 grapes, 21 raspberries, 22 strawberries, and a small collection of blackberries, currants, and gooseberries.

An apple variety orchard has been started on the Gebhardt Farm No. 2, the planting mostly having been made in the spring of 1925. Some varieties were top-worked during 1925 and 1926 on a small orchard, which was on the farm when purchased by the Experiment Station. The following varieties are now growing on the Gebhardt Farm:

Ananas Reinette
Anoka
Arkansas Black
Astrachan seedling 2391
Baldwin
Belleflower
Ben Davis
Black Ben Davis
Black Micky
Chenango
Cortland
Delicious
Delicious seedling 1940
Duchess
Early McIntosh
Early Melon
Early Red Bird
Erickson

---

[1] Connors, C. H., 1925. Peach breeding technical phase. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1924:71-72.

[2] Farley, A. J., 1923. Report of the department of pomology. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1922:81.

Fallawater
Fall Pippin
Fameuse
Gallia Beauty
Gilbert Winesap
Goldo
Gravenstein
Grimes
Henry Clay
Hoover
Hubbardston
Imperial Rambo
Jonathan
King
King David
Lobo
Lovett
Lowry
Macoun
Mammoth Black Twig (Gilbert Imp.)
Mavis
McIntosh
Medina
Melba
Milton
Nero
New Duchess
Northwestern Greening
Ohio Beauty
Ohio Nonpariel
Opalescent
Paragon
Pedro
Perfect
Ralls
Rainier
Red Astrachan
Red Gravenstein
Red McIntosh
Red Rome (From Samuel Fraser)
Red Rome (From Washington Nursery)
Red Rome (Ohio Bright Red Rome Beauty)
Red Spy
Rhode Island Greening
Rome
Roxbury
Senator
Smokehouse
Spitzenburg
Spy
Stark
Starking
Starr
Stayman
Summer Champion
Summer Rambo
Sutton
Tioga
U. S. D. A. Seedling 1
U. S. D. A. Seedling 15
Valerie
Wagener
Wealthy
Weisser Klarapfel
Westfield
White Ohio Pippin
White Winter Pearmain
Williams
Wilson Red June
Winesap
Winter Banana
Wisner Sweet
Wolf River
Yellow Newtown
Yellow Transparent
Yellow Transparent Seedling 2575
York

Nine varieties of crabapples are also growing on the Gebhardt Farm:

Dolgo
Florence
Gold
Hopa
Hyslop
Red Siberian
Transcendent
Whitney
Yellow Siberian

The following additional varieties of apples are being grown on parts of the Experiment Station grounds, other than the Gebhardt Farm:

Bay State
Bennett
Beitigheimer
Chautauqua
Clawis
Cobalt
Columbia
Daniel's Red Duchess
Ensee
Evening Party
Golden Delicious
Golden Winesap
Granny Smith
Joyce

Kildare
Maiden Blush
Medford
Mendel
Miltosh
Monmouth Pippin
Muster
Niobe
Patricia
Pedro
Petrel
Red Rambo
Smith Cider
Sonora
Stinson
Summer Extra
Summer Pearmain
Summer Pippin
Summer Pound
Sweet Nonesuch
Turley
U. S. D. A. Seedlings 2 to 14 inclusive
U. S. D. A. Seedling 16

Most of the newer varieties of apples included in the above list have not yet fruited at New Brunswick. However, two varieties; namely, Melba and Lobo, have fruited and are worthy of mention. Both are open pollinated seedlings of McIntosh originated at the Central Experimental Farm at Ottawa, Canada.

Melba is a red striped apple, medium to above medium in size which ripens during the latter part of the Williams season and before Gravenstein. It is a smooth, bright, attractive apple resembling McIntosh in perfume, flesh, and flavor, but not in general outward appearance. It is of unusual quality for such an early apple, making it particularly desirable for local and roadside markets. It is too tender for distant shipment. The trees seem to be vigorous and productive and come into bearing early.

Two Liveland Raspberry trees in the variety orchard at the Horticultural Farm top-worked to Melba in 1921 produced their first fruit in 1923. It was recommended for trial and since that time a considerable quantity of bud and cion wood has been distributed among fruit growers interested in testing the variety.

Lobo is a red apple similar to McIntosh in size and shape, but darker in color. It does not have the characteristic flavor and aroma of McIntosh, but is a firm, crisp, juicy apple of high quality. It hangs to the tree better than McIntosh. The tree resembles McIntosh in shape, vigor, and productiveness. The chief value of Lobo seems to be the fact that it hangs to the tree better than McIntosh and colors up well enough to be picked earlier than that variety. It first fruited in the variety orchard on the College Farm in 1919, and was recommended for trial the following year. Bud and cion wood has been distributed each year to a considerable number of fruit growers and nurserymen.

During the past year, several varieties have been removed from the variety orchards as unsuited for growing in New Jersey. Lack of quality and of productiveness and general inferiority to standard varieties of the same season were responsible for the removal of the following varieties:

Rensselaer
Saratoga
Broome
Nassau
Montgomery
Clinton
Otsego
Schoharie
Westchester

Grape Investigations

J. H. CLARK

Grape Pruning

Pruning studies with the grape have been carried on as outlined in last year's report.[1] It would seem desirable, however, to make no detailed report of progress until after the 1926 crop is harvested at which time three years' results will be available for compilation.

Grape Varieties

The following varieties of grapes were planted on the Horticultural Farm during the spring of 1926:

America
Armalaga
Beta
Carman
Champion
Clinton
Daisy
Lindley
Lucile
Manse
Mericadel
Pontiac
R. W. Munson
Worden

Of the 17 varieties of vinifera grapes mentioned in last year's report as being under test, the following came through the winter with practically no winter injury: Madeline Celine, Bellino, Black Monukka, Gros Sapot, and Chasselas Rose. These varieties are growing on their own roots and received no winter protection.

Small Fruit Varieties

Strawberry Varieties

The varieties of strawberries fruited at the Horticultural Farm were described by Mr. J. Harold Clark as follows:

> The spring of 1926 was rather favorable for strawberry growth, but the beds fruiting this year were not in prime condition as they were set during the abnormally dry spring of 1925. The following descriptions, therefore, especially as regards plant characters of some of the new varieties, may have to be modified after the varieties have been grown for a longer period at New Brunswick. The following varieties fruited for the first time on the Experiment Station grounds in 1926: Bun Special, Delicious, Dr. Burrill, Horsey, Jumbo, Magic Gem, Theodore Roosevelt. Additional varieties as follows were planted in 1926: Cooper, Mrs. A. F., and O. E. F.
>
> Of the newer varieties, Aberdeen is perhaps the most promising, its late season, productiveness, and attractive appearance making it desirable for home planting and for nearby markets. Howard 25 has quality, vigor, and productiveness and is desirable for home use for those who do not dislike its dark color.
>
> *Aberdeen*—Perfect. Plants numerous, may be too thick unless spaced; vigor medium to above; small, very productive; leaves small to medium, mostly light green. Fruit medium to slightly above in size; conical to narrow wedge shaped; bright attractive red; apex colors well; seeds few to medium, greenish yellow to red, slightly sunken; flesh very light red; calyx adheres well; quality fair to good; season late. Productiveness and late season make it worthy of trial for both home and commercial planting. Too soft for distant shipment. Plants secured from J. E. Kuhns, Cliffwood, N. J.

---

[1] Report of the division of horticulture. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1925: 128-129.

Barrymore—Perfect. Good plant maker; vigor medium or below; not very productive. Fruit medium or below in size; conic to narrow wedge shaped; fairly attractive color; apex ripens fairly well; seeds few; yellowish to red, sunken except at apex; calyx adheres fairly well; flesh medium to dark red, lighter at center; quality poor to fair; midseason. Too poor in quality and not productive enough to be recommended.

Bun Special—Perfect. Rather poor plant maker, fairly vigorous, moderately productive. Fruit medium size, conic to globose conic, color fairly bright red, a little too dark; apex ripens well; seeds few, sunken; flesh dark red, whitish around core; no distinctive taste, rather flat; fruit soft; early to midseason. Plants secured from Baldwin-Whitten-Ackerman, Bridgman, Michigan.

Chesapeake—A standard variety. Perfect; poor plant maker; vigorous; productive. Fruit medium size or a little above; conic wedge shaped; regular; color bright red; apex colors well; seeds evenly distributed, raised; flesh light red; apt to be hollow at center; quality good; firm, midseason to late. Plants secured from the W. F. Allen Company, Salisbury, Maryland.

Delicious—Perfect. Plants few; medium vigor; not exceptionally productive; susceptible to a physiological spotting. Fruit medium size; narrow wedge shaped; bright red; apex colors fairly well; seeds greenish yellow to reddish yellow; fairly numerous, at surface; flesh bright light red; quality very good; fruit firm; midseason. Plants secured from Baldwin-Whitten-Ackerman, Bridgman, Michigan.

Dr. Burrill—Perfect. Plants numerous; vigor medium or below; not productive; many aborted blossoms. Fruit small, conic to narrow wedge shaped; a little rough; color medium red; seeds bright greenish yellow, few to medium, at surface or just below; flesh medium to dark red; not very firm; quality fair; midseason. This variety is very similar to if not identical to Dunlap. Plants secured from Baldwin-Whitten-Ackerman, Bridgman, Michigan.

Eaton—Perfect. Fair stand of plants; medium vigor; not very productive; fruit stems short. Fruit medium size; conic to narrow wedge shaped; a little rough; color red; a little dark, apex seedy, not always coloring well; seeds numerous, greenish yellow to red, raised at apex, sunken at sides; flesh light red; quality fair; fairly firm, midseason; nothing outstanding about this variety.

Horsey—Perfect. A fair plant maker; vigorous; fairly productive. Fruit medium to large, broadly wedge shaped; a little rough; apex thick and usually indented; color fairly bright, deep red; seeds bright greenish yellow, few to medium, at surface; flesh dark red, fairly firm; quality poor to fair, early. Plants secured from J. Kiefford Hall, Reid's Grove, Maryland.

Howard 17 (*Premier*)—Perfect. A very good plant maker; vigorous; very productive. Fruit medium to above; conic; regular, large berries apt to have sunken place in each side; attractive bright red; apex ripens well, seeds bright greenish yellow, slightly sunken; flesh light red; quality poor to fair; very early; late pickings size up well. One of the best commercial varieties for New Jersey. Plants secured from W. F. Allen Company, Salisbury, Maryland.

Howard 25—Imperfect. Plants numerous; very vigorous; above average productiveness; fruit medium size to slightly above; conic. Rather smooth and regular; color dark red; unattractive; apex colors well; seeds greenish yellow, slightly sunken; flesh dark red; very good quality; very early; greatest drawback is the dark color. Plants secured from W. B. Howard, Belchertown, Massachusetts.

Hunterdon—Imperfect. Plants numerous; medium vigor; productive; susceptible to physiological spotting. Fruit medium to large; conic but many berries irregular; color bright red, attractive; apex ripens fairly well; seeds bright yellowish green to greenish red; flesh light red; whitish core; quality fair or a little below; rather soft; midseason to late. Plants secured from T. R. Hunt, Lambertville, New Jersey.

Joe—A standard variety. Perfect. Good plant maker; vigorous; productive. Fruit medium to large; mostly roughly wedge shaped, some almost conic; attractive bright red color; apex apt not to color up well; flesh light red; light red to whitish core; quality very good; firm; midseason to late. Plants secured from the W. F. Allen Company, Salisbury, Maryland.

Jumbo—Perfect fairly good plant maker; medium vigor or above; productive; fruit very large; wedge shaped; rough, irregular, ridged; bright red; apex does not always color up well; seeds greenish yellow to red; numerous; raised slightly; flesh bright red; quality poor to fair; midseason to late. Plants secured from L. J. Farmer, Pulaski, New York.

Lupton—A standard variety. Perfect. Plants numerous; vigorous; productive; not many berries per fruit stem. Fruit large; irregularly wedge shaped; bright, light red; apex does not always color well; seeds yellowish to red, raised; flesh light red, spongy; soon gets mealy; quality poor; large berries often hollow; late. Plants secured from the W. F. Allen Company, Salisbury, Maryland.

Magic Gem—Perfect. Fair plant maker, medium vigor; not productive; fruit small to medium; conic to oblate conic; fairly uniform; color an unattractive red; apex colors well; seeds numerous, yellowish green to red, at surface; flesh light red; quality fair to medium; midseason. Plants secured from the R. M. Kellogg Company, Three Rivers, Michigan.

Sweet Belle—Perfect. Plants numerous; vigorous; not productive; many aborted flowers. Fruit small; globose conic, necked; light red; apex colors well; seeds medium number, yellowish to red, raised; flesh light red; quality fair to good, sweet when ripe; calyx separates readily from fruit; early. This variety has been discarded at the Experiment Station farm mainly because of its lack of productiveness. Plants secured from Preston Smith, Ashley, Ohio.

Theodore Roosevelt—Imperfect. Plants numerous; medium to vigorous; productive; many berries per fruit stem. Fruit small, mostly narrow wedge shaped; a little irregular; seeds numerous, raised, greenish yellow to red; flesh very light red; calyx does not adhere tightly; quality fair; firm; midseason to late. Plants secured from David Knight & Son, Sawyer, Michigan.

Wyona—Perfect. Good plant maker; vigor medium; productiveness below medium; somewhat susceptible to leaf spot. Fruit medium size to slightly above; very irregular and rough; broadly wedge shaped; apex does not color well; seeds failing to develop form a small black mass at the tip; many berries hollow with hollow open to outside; color bright red; seeds numerous, yellowish to red, raised; flesh bright red; quality fair to good; very late. Plants secured from A. S. Johnson, Washington, D. C.

Raspberry and Blackberry Varieties

The varieties of brambles formerly growing on the Wolpert Farm have been moved to Gebhardt Farm No. 2, since the latter has been available for use by the department of pomology. The following varieties are now being grown:

Red Raspberries

VARIETY	SOURCE OF PLANTS
Herbert	George B. Aiken, Putney, Vt.
Latham	Samuel Fraser, Geneseo, N. Y.
Redpath	Samuel Fraser, Geneseo, N. Y.
Newman 20	C. P. Newman, Ville Lasalle, Quebec.
Newman 23	C. P. Newman, Ville Lasalle, Quebec.
Marlboro	George B. Aiken, Putney, Vt.
King	Baldwin-Whitten-Ackerman, Bridgman, Mich.
Donboro	J. E. Kuhns, Cliffwood, N. J.
Cuthbert	Baldwin-Whitten-Ackerman, Bridgman, Mich.
Viking	Agricultural Experiment Station, Vineland, Ont.
Fewthorn	Carl A. Hansen Nursery, Brookings, S. D.
Twilight	Carl A. Hansen Nursery, Brookings, S. D.
Ohta	Carl A. Hansen Nursery, Brookings, S. D.
Spineless	Carl A. Hansen Nursery, Brookings, S. D.
Sunbeam	Carl A. Hansen Nursery, Brookings, S. D.
Smooth Cane	Carl A. Hansen Nursery, Brookings, S. D.
Starlight	Carl A. Hansen Nursery, Brookings, S. D.

Purple Cane Raspberries

VARIETY	SOURCE OF PLANTS
Royal Purple	George B. Aiken, Putney, Vt.
Brant	New York State Fruit Testing Cooperative Association, Geneva, N. Y.

Black Raspberries

VARIETY	SOURCE OF PLANTS
Uncle Tom	T. R. Hunt, Lambertville, N. J.

Blackberries

VARIETY	SOURCE OF PLANTS
Edward Langley	United States Department Agricultural Introduction.
Best of All	Benjamin Barrett, Blue Anchor, N. J.
Russell's Pride	J. Frank Russell, Sicklerville, N. J.

Blooming Dates of Apples in Various Sections of New Jersey, 1926

Variety	Newton Sussex Co.		Lebanon Hunter. Co.		New Bruns. Midd. Co.		Hightstown Mercer Co.		Manasquan Mon. Co.		Middletown Mon. Co.		Bridgeton Cumber. Co.		Pleasantville Atlantic Co.	
	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom
Baldwin	5-13	5-19	5-12	5-14	5-8	5-12	5-9	5-11	5-11	5-14	5-5	5-10	—	—	5-5	5-9
Ben Davis	—	—	—	—	—	—	—	—	5-11	5-15	5-5	5-10	5-3	5-8	—	—
Delicious	—	—	5-12	5-15	5-9	5-14	5-8	5-10	5-11	5-15	5-5	5-10	5-3	5-8	5-6	5-11
Duchess	—	—	5-11	5-14	5-6	5-10	5-7	5-9	5-6	5-10	5-3	5-10	5-1	5-4	5-1	5-5
Golden Delicious	—	—	—	—	—	—	—	—	—	—	—	—	5-3	5-8	—	—
Gravenstein	—	—	5-10	5-12	5-6	5-10	5-7	5-9	—	—	5-3	5-10	4-30	5-4	5-3	5-9
Grimes	5-13	5-17	5-11	5-13	5-11	5-13	5-8	5-10	5-9	5-13	—	—	5-2	5-7	5-4	5-10
Jonathan	5-13	5-19	5-12	5-14	5-9	5-13	5-8	5-10	5-11	5-15	5-5	5-10	5-3	5-8	—	—
King	—	—	—	—	5-7	5-10	—	—	—	—	—	—	—	—	—	—
McIntosh	5-13	5-17	5-11	5-13	5-8	5-12	5-7	5-9	5-8	5-11	5-3	5-10	5-3	5-7	—	—
Paragon	5-13	5-17	5-12	5-14	5-8	5-13	5-8	5-11	5-9	5-13	—	—	5-2	5-8	—	—
Red Astrachan	5-10	5-15	5-11	5-13	5-6	5-10	—	—	5-6	5-11	5-3	5-10	4-29	5-3	5-2	5-5
Rome	5-13	5-19	5-13	5-18	5-10	5-16	5-10	5-14	5-11	5-16	—	—	5-3	5-9	—	—
R. I. Greening	5-13	5-19	5-12	5-14	5-9	5-13	5-10	5-12	5-11	5-14	—	—	—	—	—	—
Stark	—	—	5-11	5-14	5-8	5-13	5-8	5-10	—	—	5-5	5-10	5-2	5-7	—	—
Starr	—	—	5-12	5-15	—	—	5-6	5-9	5-13	5-17	5-5	5-10	5-1	5-6	—	—
Stayman	5-13	5-17	5-11	5-13	5-9	5-14	5-8	5-11	5-8	5-12	5-5	5-10	5-2	5-8	5-4	5-9
Transparent	5-13	5-17	5-10	5-13	5-7	5-11	5-5	5-7	5-9	5-12	—	—	5-2	5-7	5-7	5-11
Wealthy	—	—	5-10	5-13	5-8	5-12	5-10	5-14	5-8	5-13	5-5	5-10	5-3	5-8	5-7	5-12
Williams	—	—	5-10	5-13	5-11	5-17	5-10	5-14	—	—	—	—	5-3	5-10	5-9	5-15
Winesap	—	—	—	—	—	—	5-8	5-10	5-11	5-14	—	—	5-3	5-8	—	—
York	—	—	5-13	5-18	—	—	5-10	5-14	5-11	5-16	—	—	5-3	5-10	—	—
Approximate date for majority of varieties	5-13	5-17	5-11	5-13	5-9	5-13	5-8	5-11	5-11	5-14	5-5	5-10	5-3	5-8	5-6	5-11
Delayed dormant spray	4-23		4-23 & 4-24		4-12		4-12—4-19		4-2 & 4-3		4-12		4-7 —4-12			
Pink bud spray	5-7		5-7 & 5-8		5-7		5-3 —5-5		5-5 & 5-6		4-29		4-23—4-29		4-26—5-5	
Petal fall spray	5-25		5-21 & 5-24		5-20		5-15—5-21		5-18 & 5-21		5-17—5-21		5-12—5-15		5-3 —5-22	

Blooming Dates of Peaches in Various Sections of New Jersey, 1926

Variety	Lebanon Hunter. Co.		New Bruns. Midd. Co.		Middletown Mon. Co.		Manasquan Mon. Co.		Westville Glouc. Co.		Hammonton Atlantic Co.		Bridgeton Cumber. Co.		Swainton Cape May Co.	
	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom	First bloom	Full bloom
Arp Beauty	—	—	5-2	5-5	—	—	4-28	5-1	4-23	5-1	—	—	4-22	4-27	4-21	4-24
Belle of Georgia	5-7	5-10	5-1	5-5	4-26	5-1	4-27	5-3	4-23	4-30	4-24	4-25	4-22	4-28	4-21	4-29
Carman	5-8	5-11	5-1	5-5	—	—	4-26	5-3	4-23	4-30	4-23	4-26	4-21	4-27	4-21	4-24
Cumberland	—	—	5-2	5-5	—	—	4-28	5-10	4-23	4-30	—	—	4-21	4-29	—	—
Elberta	5-6	5-9	4-29	5-3	4-26	5-1	4-27	5-2	4-22	4-28	4-24	4-25	4-22	4-26	4-21	4-29
Fox Seedling	—	—	5-2	5-5	4-26	5-1	4-30	5-6	4-23	4-28	4-25	4-26	4-22	4-29	4-21	4-29
Greensboro	5-7	5-10	5-1	5-5	—	—	4-26	5-3	4-23	4-30	4-23	4-26	—	—	4-21	4-29
Hale	5-7	5-10	5-2	5-5	—	—	4-27	5-3	4-23	4-30	—	—	4-22	4-27	—	—
Hiley	5-6	5-11	5-1	5-5	4-26	5-1	4-25	5-3	4-23	5-1	4-22	4-25	4-21	4-27	4-21	4-29
Iron Mountain	5-8	5-12	5-2	5-5	4-26	5-1	4-27	5-6	—	—	—	—	4-23	5-1	4-21	4-29
Krummel's Oct.	5-8	5-14	5-2	5-5	—	—	4-28	5-6	—	—	—	—	4-22	4-29	—	—
Pioneer	5-9	5-13	5-2	5-5	—	—	5-3	5-8	4-22	4-28	—	—	4-22	4-30	—	—
Approximate date for majority of varieties	5-7	5-11	5-2	5-5	4-26	5-1	4-27	5-3	4-23	4-30	4-24	4-26	4-22	4-27	4-21	4-29
Dormant spray	4-5 & 4-6		3-21		3-27		3-22—3-23		3-19—3-30		Fall 1925		11-25—3-26		3-12	
Petal fall spray	5-12 — 5-20		—		—		5-6 —5-13		5-3 —5-5		—		4-30—5-3		5-3	
Shuck fall spray	5-27 — 5-29		5-22		5-22		5-19—5-24		5-15—5-18		5-13—5-17		5-15—5-19		5-18	

Report of Weather Observations

CLARENCE H. STEELMAN

The year ending June 30, 1926, was the driest we have on record, the precipitation totaling only 33.73 inches. This is 13.71 inches below the normal of 47.44. The rainfall for the months of July, August, and September was only 9.85 inches. The normal precipitation for these three months is 16.14 inches. A very serious shortage of water for all purposes was caused by a warm and dry June, followed by this period of dry weather.

The records show that the rainfall has been below normal for each of the past five years. The yearly average during this period was 39.62 inches, or 7.82 inches below normal. The precipitation records for this period show a shortage of 39.10 inches, which is almost equal to one year's water supply. An unusually strong wind on October 10 caused serious damage by blowing off many winter apples. The wind was so strong that it blew off small branches as well as fruit, tore the leaves, and left the stems attached to the twigs. It was also very cold for early October, the minimum on the tenth being 30° F., and the maximum only 51°.

The spring was very backward and on June 30, the season is still about ten days later than normal. It was very cool and dry during March, April, May, and June. The mean temperature for these four months was 3° F. below normal. The precipitation was 6.09 inches below normal.

The greatest amount of rainfall in 24 hours was 1.51 inches on October, 25, 1925.

There was 28.85 inches of snow during the winter, of this amount 23.7 inches fell in February.

The mean temperature for the year was 50.40° F., which is 1.3° F., below normal.

The last killing frost occurred on April 27, 1926, and the first killing frost occurred on October 24, 1925.

Mean Temperature for 1925-26 *Compared With Normal*

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Mean temperature 1925-26	72.6	71.2	68.16	49.16	42.33	33.8	30.79	29.1	35.6	46.7	59.9	64.9
Normal mean temperature	74.9	72.4	66.3	55.4	43.6	32.	29.7	27.8	38.2	49.7	62.4	68.8

Monthly Maximum and Minimum Means of Temperature for the Year Ending June 30, 1926

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Maximum ...	83.6	82.9	78.1	58.45	51.73	40.2	38.77	37.1	46.1	57.3	73.4	76.4
Minimum	61.6	59.5	58.23	39.87	32.93	27.4	22.81	21.1	25.2	36.	46.3	53.4

Daily and Monthly Precipitation at the College Farm for the Year Ending June 30, 1926

Date	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1	—	.78	—	—	—	.06	—	.41	—	.14	.03	T
2	.01	—	—	—	T	T	—	—	.06	—	—	.28
3	—	—	.02	.54	.04	1.09	—	T	—	T	—	.16
4	—	—	—	.23	—	.79	.01	.98	—	.25	—	—
5	.45	.21	—	.37	—	.02	.19	—	—	—	—	.08
6	—	.02	T	—	.18	.02	—	—	—	—	—	—
7	—	—	1.30	—	—	—	—	—	.93	.04	—	.17
8	.10	—	—	—	.24	—	—	—	.23	.43	—	.04
9	.03	.32	—	.21	—	—	.17	.02	—	.23	—	.03
10	.45	.34	—	T	—	T	—	.49	—	—	—	T
11	—	.02	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	.07	—	—	—	—	—	—	.08
13	—	.13	—	—	1.11	—	—	.01	—	—	—	.03
14	—	.69	.16	—	—	—	—	.19	—	—	.30	—
15	T	—	—	.88	—	—	—	.28	—	—	.02	.11
16	.08	—	.85	—	.36	—	—	—	—	—	.87	—
17	.40	—	1.09	1.04	—	—	—	—	—	—	.08	—
18	—	—	—	—	—	—	.38	—	—	—	—	—
19	—	—	—	—	—	—	.20	.24	—	—	.14	—
20	—	—	—	—	—	—	—	T	.01	—	.17	—
21	.08	.30	—	—	—	.09	.16	—	T	—	—	—
22	.03	—	—	T	—	.20	.49	—	—	—	—	.02
23	.02	—	—	.04	—	—	—	.10	.12	T	.02	1.41
24	—	—	—	.18	—	—	—	—	—	—	—	—
25	.41	—	—	1.51	.12	T	—	.53	—	.65	—	—
26	.49	—	—	—	T	T	—	.08	.34	—	—	.23
27	.06	—	—	—	.36	T	T	—	T	—	—	.06
28	—	—	—	—	—	—	T	—	—	.05	—	—
29	.17	—	—	—	—	—	—	—	—	—	—	—
30	—	—	—	.18	—	—	—	—	—	T	—	—
31	.80	.04	—	.04	—	—	.49	—	.20	—	.48	—
Total	3.58	2.85	3.42	5.22	2.48	2.27	2.09	3.33	1.89	1.79	2.11	2.70
Normal	6.42	5.75	3.97	4.11	3.30	3.74	3.28	3.61	4.08	3.45	3.72	3.33

REPORT OF THE VEGETABLE DEPARTMENT

L. G. SCHERMERHORN

The investigational projects of the vegetable department in 1925 were continued with only a few changes. The fertilizer experiments with cauliflower formerly conducted on the farm of G. L. Fisher at Athenia, N. J., were transferred to New Brunswick, and were continued here in 1925.

The sweet potato studies begun in 1921 were continued at only one point in the state in 1925, on the farm of Charles Underhill at Lakewood and will be discontinued during the season of 1926, as the work has gone as far as possible with field experiments. Dr. W. Rei Robbins will continue the sweet potato studies under controlled conditions in the greenhouses at New Brunswick to measure the influence of potash and moisture upon the yield and shape of the sweet potato.

During the year, a cooperative study was begun with Dr. G. T. Nightingale to determine under controlled and field conditions the optimum time for the application of nitrates to asparagus.

Plant-Food Studies With Carrots

Project 13—Experiment 1

The growing of carrots on one-half of this series of plots was continued in 1925 with the Chantenay variety. The seed for the carrot crop was sown June 18, 1925, in 6 rows 30 inches apart and the plants were thinned to stand 3 to 4 inches in the rows. Because of the extremely dry weather at planting it was necessary to make a second sowing of seed on July 12, 1925. The drought which continued throughout the summer accounts for the smaller yields per acre obtained in 1925 as compared with 1924.

TABLE 1

Plant Food Studies With Carrots—1925

Plot	Fertilizer Treatment	Yields per Acre			
		Series A	Series B	Average	
		bushels	*bushels*	*bushels*	*tons*
1	Check		119.5	119.5	2.99
2	600 lbs. A.P.*	187.	110.	148.5	3.71
3	800 lbs. A.P.	70.	97.5	83.75	2.09
4	1000 lbs. A.P.	51.5	119.5	85.5	2.14
5	600 A.P. 100 KCl	96.	131.5	113.75	2.84
6	800 A.P. 100 KCl	86.	119.	102.5	2.56
7	1000 A.P. 100 KCl	103.	116.5	109.75	2.74
8	Check	29.	18.	23.5	.59
9	600 A.P. 200 KCl	135.5	148.5	142.	3.55
10	800 A.P. 200 KCl	135.	150.5	142.75	3.57
11	1000 A.P. 200 KCl	92.5	104.	98.25	2.45
12	800 A.P. 200 KCl 100 $NaNO_3$	264.5	247.5	256.	6.40
13	800 A.P. 200 KCl 200 $NaNO_3$	228.5	234.5	231.5	5.79
14	800 A.P. 200 KCl 150 $NaNO_3$ 37½ $(NH_4)_2SO_4$	206.	216.5	211.25	5.28
15	800 A.P. 200 KCl 100$NaNO_3$ 75 $(NH_4)_2SO_4$	184.5	214.	199.25	4.98
16	800 A.P. 200 KCl 150 $(NH_4)_2SO_4$	142.5	203.	172.75	4.32
17	800 A.P. 100 KCl 150 $NaNO_3$ 150 Fish	130.5	220.	175.25	4.38
18	800 A.P. 200 KCl 100 $NaNO_3$ 200 Fish	157.5	226.5	192.	4.80
19	800 A.P. 200 KCl 50 $NaNO_3$ 300 Fish	186.	220.	203.	5.07
20	80 A.P. 200 KCl 400 Fish	171.5	226.5	199.	4.97
21	Check	46.5	47.	46.75	1.17
22	800 A.P. 200 KCl 100 $NaNO_3$, 37½ $(NH_4)_2SO_4$, 100 Fish	138.	199.5	168.75	4.22

*A.P.=Acid Phosphate.

The results indicate the relative importance of the fertilizing ingredients used as follows:

	tons
No fertilizer—Average of all checks	1.58
800 pounds per acre of Acid Phosphate	2.09
800 pounds per acre of Acid Phosphate, 100 pounds KCl	2.56
800 pounds per acre of Acid Phosphate, 200 pounds KCl	3.57
800 pounds per acre of Acid Phosphate, 200 pounds KCl 100 pounds $NaNO_3$	6.40
800 pounds per acre of Acid Phosphate, 200 pounds KCl 200 pounds $NaNO_3$	5.79

These results parallel those secured in 1924.

The complete records of the fertilizer comparisons with carrots at New Brunswick will be found in table 1.

Celery

The half of each of the plots in the tomato experiment which had been planted to carrots in 1924 was set with celery in 1925. The area in celery on each plot was approximately 1/100 acre.

Seed of the Golden Plume variety of celery was sown in flats in the greenhouse April 25, and the plants were later transplanted into other flats and spaced 2 by 2 inches. They were set in the field 8 inches apart in 3½-foot rows. In harvesting, the plants were pulled, dirt was shaken from the roots, and only the dried leaves were broken off. A truer estimate of the value of the fertilizer treatments is obtained by this method than where the celery is closely trimmed. The results indicate the value of potash for this crop. Nitrate of soda proved to be the best source of nitrogen.

Plant-Food Studies With Sweet Potatoes

Project 15

The fertilizer comparison with sweet potatoes in 1925 was carried on at the farm of Charles Underhill, at Lakewood, N. J. Studies relating to the influence of potash, phosphoric acid, and time of applying nitrogen on sweet potato production were continued in 1925. The sources of potash compared in 1925 were muriate, sulfate, kainit, and manure salts.

The results secured are similar to those of other years, although the effect of potash on yield is not so striking because of the very dry season and the difficulty experienced in getting a stand of plants. The rows were made up 3½ feet apart and the plants set 18 inches apart in the rows. The plots consisted of 187 plants, or 1/40 of an acre. The plants were set May 18, and dug October 13, 1925.

The yields indicate very clearly the necessity of securing a good stand at the first planting as the replants amounted to almost nothing and the yield is reduced proportionately.

The influence of the potash on the shape of the sweet potato prevailed in spite of the unfavorable season.

TABLE 2

Plant Food Studies With Celery—New Brunswick, 1925
Showing the Average Weight of Marketable Stalks and the Total Weight Per Plot (1/100 Acre)

Plot	Fertilizer Treatment	Series A		Series B		Average	
		Av. Wt. of Stalk	Yield Per Plot	Av. Wt. of Stalk	Yield Per Plot	Av. Wt. of Stalk	Yield Per Plot
		pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
1	Check	—	—	0.85	80.8	0.85	80.8
2	600 lbs. A.P.	1.03	117.2	—	72.5	1.03	94.9
3	800 lbs. A.P.	—	66.5	—	63.5	—	65.0
4	1000 lbs. A.P.	—	74.5	—	66.0	—	70.3
5	600 lbs. A.P., 100 lbs. KCl	0.78	93.8	0.91	75.3	0.95	84.6
6	800 lbs. A.P., 100 lbs. KCl	0.81	92.0	0.91	88.3	0.86	90.2
7	1000 lbs. A.P., 100 lbs. KCl	0.70	86.0	0.88	95.5	0.79	90.8
8	Check	—	49.5	—	51.8	—	50.7
9	600 A.P., 200 KCl	1.00	147.8	0.91	131.3	0.96	139.6
10	800 A.P., 200 KCl	1.00	134.6	1.00	146.5	1.00	140.6
11	1000 A.P., 200 KCl	0.70	96.0	1.00	133.0	0.85	114.5
12	800 A.P., 200 KCl, 100 $NaNO_3$	1.51	251.8	1.24	205.3	1.38	228.6
13	800 A.P., 200 KCl, 200 $NaNO_3$	1.45	250.3	1.43	230.7	1.44	240.5
14	800 A.P., 200 KCl, 150 $NaNO_3$, 37½ $(NH_4)_2SO_4$	1.45	233.4	1.38	223.3	1.42	228.4
15	800 A.P., 200 KCl, 100 $NaNO_3$, 75 $(NH_4)_2SO_4$	1.34	225.9	1.49	210.0	1.42	218.0
16	800 A.P., 200 KCl, 150 $(NH_4)_2SO_4$	1.12	172.0	1.00	205.3	1.06	188.7
17	800 A.P., 200 KCl, 150 $NaNO_3$, 100 Fish	1.13	195.3	1.55	246.0	1.34	220.7
18	800 A.P., 200 KCl, 100 $NaNO_3$, 200 Fish	1.09	168.3	1.56	244.0	1.33	206.2
19	800 A.P., 200 KCl, 50 $NaNO_3$, 300 Fish	1.14	174.6	1.29	216.7	1.22	195.7
20	800 A.P., 200 KCl, 400 Fish	1.16	162.3	1.26	194.0	1.21	178.2
21	Check	—	57.3	—	75.3	—	66.3
22	800 A.P., 200 KCl, 100 $NaNO_3$, 37½ $(NH_4)_2SO_4$, 100 Fish	0.94	128.0	1.40	203.7	1.17	165.9

TABLE 3

Plant-Food Studies With Sweet Potatoes—Ocean County, 1925

Fertilizer Treatments	Yields per Acre					
	Series A		Series B		Average	
	Firsts	Seconds	Firsts	Seconds	Firsts	Seconds
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1400 lbs. 3-8-0	108.2	107.0	203.7	48.0	155.9	77.5
1400 lbs. 3-8-4	171.7	126.3	153.3	69.9	162.5	98.1
1400 lbs. 3-8-6	192.1	97.6	198.2	69.4	195.1	83.5
1400 lbs. 3-8-8	213.3	92.4	166.1	99.5	189.7	95.9
1400 lbs. 3-8-10	301.9	56.6	230.5	38.1	266.2	47.3
1400 lbs. 0-8-8	292.7	88.7	209.4	98.1	251.0	93.4
1400 lbs. 3-0-8	242.8	65.8	203.6	78.9	223.2	72.3
1800 lbs. 3-8-8	250.8	98.0	241.3	71.4	246.0	84.7
700 lbs. 3-8-8	245.6	33.6	186.8	52.6	216.2	43.1
1400 lbs. 3-4-8	224.2	93.6	236.6	75.2	230.4	84.4
1400 lbs. 3-8-8 Manure Salts as Filler	267.0	65.0	203.4	68.3	235.2	66.6
1400 lbs. 3-8-8 Manure Salts as Source of Potash	144.1	60.4	178.8	70.0	161.5	65.2
1400 lbs. 5-8-8	265.7	35.9	195.7	52.2	230.7	44.0
1400 lbs. 8-8-8	232.7	64.1	208.5	62.9	220.6	63.5
Check	231.9	43.7	230.5	42.9	231.2	43.3
1400 lbs. 3-8-8 Kainit	199.4	66.8	213.9	61.1	206.6	63.9
1400 lbs. 3-8-8 Sulfate of Potash	219.6	117.8	234.6	76.6	227.1	97.2
600 A.P. 200 KCl 100 $NaNO_3$	231.3	108.0	207.9	29.9	219.6	68.9
600 A.P. 200 KCl 200 $NaNO_3$	306.7	108.0	142.3	71.5	224.5	89.7
600 A.P. 200 KCl 300 $NaNO_3$	102.3	90.6	140.4	84.0	121.3	87.3
300 A.P. 100 KCl 50 $NaNO_3$ Same as Side Dressing	201.3	72.3	199.4	48.5	200.3	60.4

TABLE 4

Plant Food Studies With Asparagus—New Brunswick, 1925

Plot	Fertilizer Treatments	Morrisey Farm			Wolpert Farm		
		Y'd per Acre in 2-lb. Bunches			Y'd per Acre in 2-lb. Bunches		
		Firsts	Seconds	Total	Firsts	Seconds	Total
1	Manure—10 tons per acre	1441.5	946.5	2388.0	1437.0	638.5	2075.5
2	Manure 10 tons and 750 pounds A.P.; 150 pounds $NaNO_3$ in the spring and 250 pounds $NaNO_3$ after cutting	1548.5	994.0	2542.5	1520.0	787.5	2307.5
3	Manure 10 tons and 750 pounds A.P. All in spring	1593.2	1078.2	2671.4	1487.5	745.0	2241.5
4	Manure 10 tons in spring and 1500 pounds 4-8-4. All after cutting	1645.0	1047.7	2692.7	1610.0	766.5	2376.5
5	Manure 10 tons and 500 pounds 4-8-4 (spring) and 1000 pounds 4-8-4 after cutting	1710.7	1056.2	2766.9	1707.5	744.5	2452.0
6	Manure 10 tons in spring and 750 pounds 4-8-4 after cutting	1764.0	1097.7	2761.7	1480.5	577.0	2057.5
7	Manure 10 tons and 500 pounds 4-8-4 (spring); 1000 pounds 4-8-4 after cutting and leguminous cover crop	1624.2	1031.7	2655.9	1442.0	562.5	2004.5
8	Same as plot 7 and non-leguminous cover crop	1655.7	909.0	2564.7	1199.5	453.5	1653.

TABLE 5

Plant Food Studies With Asparagus—Gloucester County, 1925

Plot		ACTUAL YIELD PER PLOT								YIELD PER ACRE					
		SERIES II				SERIES I				SERIES I		SERIES II		AVERAGE	
		Firsts		Seconds		Firsts		Seconds		1sts	2nds	1sts	2nds	1sts	2nds
		lbs.	*ozs.*	*lbs.*	*ozs.*	*lbs.*	*ozs.*	*lbs.*	*ozs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	1500 pounds 5-8-0	8	6.0	6	13.0	6	10.5	6	4.0	335.0	272.5	300.6	261.2	266.2	250.0
2	1500 pounds 5-8-3	10	1.0	9	7.0	5	4.0	6	13.0	402.2	377.5	306.1	325.0	210.0	272.5
3	1500 pounds 5-8-5	11	1.0	8	1.0	4	13.0	6	18.0	442.5	322.5	322.5	303.7	192.5	285.0
4	1500 pounds 5-8-7	9	6.0	10	1.5	6	..	6	3.0	375.0	460.0	323.7	358.7	272.5	247.5
5	1500 pounds 5-8-7 and 250 $NaNO_3$ After Cutting	9	15.0	8	12.0	5	5.0	7	14.0	397.5	350.0	305.0	332.5	212.5	315.0
6	1500 pounds 5-8-7 ½ Spring, ½ After Cutting	10	9.0	7	14.0	5	2.5	7	6.0	422.5	315.0	314.3	305.0	206.2	295.0
7	1500 pounds 5-8-7 All After Cutting	10	13.0	8	11.0	6	14.0	6	8.0	432.5	347.5	353.7	297.7	275.0	248.0
8	1500 pounds 5-8-5 Manure Salts	9	6.5	6	6.5	6	14.0	5	14.0	376.2	256.2	325.6	245.6	275.0	235.0
9	1500 pounds 5-8-7 Manure Salts	8	1.0	7	3.0	8	6.0	6	4.5	322.5	288.5	328.7	269.8	335.0	251.2
10	1500 pounds 5-8-3 Kainit	10	15.0	6	10.5	6	15.0	6	12.5	437.5	282.2	357.5	277.0	277.5	271.8
11	1500 pounds 5-8-5 Kainit	11	1.0	9	9.5	7	3.0	7	10.5	477.5	383.7	382.5	344.9	287.5	306.2
12	1500 pounds 5-8-7 Kainit	9	7.5	7	11.0	4	13.0	6	14.0	378.7	307.5	285.6	291.2	192.5	275.0
13	2000 pounds 5-8-7 Muriate	10	9.5	8	4.0	6	5.0	7	15.0	423.7	330.0	338.1	32[illegible]	252.5	317.5
14	3000 pounds 5-8-7 Muriate	10	6.0	7	6.0	7	4.0	7	15.0	415.0	295.0	352.5	303.2	290.0	317.5
15	1500 pounds 5-8-7 and 1 ton Lime	10	9.0	8	4.0	5	11.0	7	4.0	422.5	330.0	325.0	310.0	227.5	290.0
16	1500 pounds 5-8-7 and 2 tons Lime	9	10.0	7	12.0	6	2.5	7	1.5	385.0	310.0	315.3	296.5	245.6	283.1
17	1500 pounds 0-8-7 All in Spring	8	7.5	8	8.0	7	1.0	7	8.0	338.5	340.0	310.5	320.0	282.5	300.0
18	1500 pounds 3-8-7 All in Spring	10	11.0	8	9.0	7	11.5	7	6.5	427.5	342.5	368.1	319.3	308.7	296.2
19	1500 pounds 9-8-7 All in Spring	10	7.0	8	13.0	5	12.5	9	6.0	417.5	352.5	324.3	363.7	231.2	375.0
20	460 pounds $NaNO_3$ 300 pounds A.P., 260 pounds KCl	10	3.5	9	3.5	6	..	9	11.5	408.7	368.7	324.3	378.7	240.0	388.7
21	1500 pounds 5-0-7	7	7.0	9	5.0	8	6.0	8	7.0	297.5	372.5	316.2	355.0	335.0	337.5
22	1500 pounds 5-4-7	9	11.5	10	8.0	5	10.5	8	14.0	388.7	420.0	307.4	387.5	226.2	355.0
23	1500 pounds 5-8-7 and 500 pounds NaCl	9	12.5	9	12.5	3	12.0	6	13.5	401.5	401.5	275.7	292.6	150.0	183.7
24	1500 pounds 5-8-7 and 1000 pounds NaCl	7	11.0	9	13.0	8	4.0	7	1.5	307.5	392.5	318.7	338.1	330.0	283.7
25	1500 pounds 5-8-7 Cowpeas—August 15	12	10.0	11	7.5	9	2.0	9	7.0	505.0	458.7	435.0	418.1	365.0	377.5
26	1500 pounds 5-8-7 Oats—August 15	9	8.5	9	1.0	8	3.0	8	..	381.1	362.5	354.3	341.2	327.5	320.0
27	1500 pounds 5-8-7 Spring Vetch—August 15	11	5.5	11	3.0	6	7.0	6	14.5	453.7	447.5	355.6	361.8	257.5	276.1
28	1500 pounds 5-8-7 Cowpeas	9	4.0	9	0.5	3	2.0	10.0	7.0	370.0	361.2	247.5	389.3	125.0	417.5
29	1500 pounds 5-8-7 Oats	9	3.5	8	8.0	7	10.0	9	3.0	368.7	340.0	336.8	353.7	305.0	367.5
30	1500 pounds 5-8-7 Spring Vetch	9	2.5	8	11.0	4	12.5	9	8.0	366.2	347.5	278.7	363.7	191.2	380.0
31	1500 pounds 5-8-7 Millet	7	14.0	9	6.5	3	7.0	8	6.5	315.0	376.2	226.2	356.2	137.5	336.2
32	1500 pounds 5-8-7 Cowpeas—August 15, ½ Spring, ½ After Cutting	8	5.0	10	2.0	5	9.0	7	12.0	332.5	405.0	277.5	357.5	222.5	310.0

The complete results of the fertilizer comparison may be found in table 3.

The greatest loss of plants was on those plots receiving Kainit and manure salts as a source of potash. On the Kainit plots, 60.4 per cent were replanted; and on the manure salts plot, 41.7 per cent were replanted; whereas on the check plots, only 11.2 per cent were replanted; and on the no potash plot, only 18.1 per cent were replanted.

Plant-Food Studies With Asparagus

Project 19

Experiment 1—This series of plant-food studies with asparagus begun in 1922 on the Horticultural Farms at New Brunswick was continued in 1925.

The decrease in yield noted on the plots where green manure crops have been sown in the asparagus over a 3-year period occurred again in 1925.

The results secured in 1925 are given in table 4.

Experiment 2—The plant-food studies with asparagus in Gloucester County were continued in 1924, and the first records were secured over a period extending from April 24 to May 30. The first full cutting season will be reached in 1926.

The yields shown in table 5 show that the land on which the work is being conducted is very uniform—there being only slight differences in yields as might be expected at this stage of the experiment. The yields secured in 1925 will be found in table 5.

Plant-Food Studies With Cantaloupes

Project 20

The cantaloupe studies in 1925 included (1) comparisons of plants started under glass with field planted plants and (2) fertilizer comparisons.

The results secured in 1925 were similar to those secured in the three previous years, the veneer band plants beginning to pick 2 weeks earlier than the plants from the field planted seed. The variety used was Hearts of Gold.

Table 6 gives fertilizer treatments and yields. The outstanding feature of the fertilizer study in 1925 is the fact that in the extremely dry weather prevailing during the cantaloupe growing season in 1925 the plots that have been receiving stable manure during the past four years showed an increase in yield over plot 9 which has been the outstanding treatment for the three previous years during which time we had a normal rainfall.

TABLE 6

Cantaloupe Studies—1925
Veneer Band vs. Field Planted Seed and Fertilizer Studies

Fertilizer	Method of Starting the Plants	⅝-Bushel Baskets Per Acre					
		Series A		Series B		Average	
		1sts	2nds	1sts	2nds	1sts	2nds
Manure alone	Veneer Bands	257.7	133.3	281.0	155.5	269.5	144.4
Manure alone	Field Planted	169.0	91.9	91.5	68.6	130.2	80.2
Manure and 500 pounds A. P.	Veneer Bands	340.2	131.0	177.5	204.1	258.8	167.5
Manure and 500 pounds A. P.	Field Planted	181.3	115.4	125.8	94.4	153.5	104.9
Manure and 500 pounds 4-8-4	Veneer Bands	251.5	60.0	193.5	119.3	222.5	89.6
Manure and 500 pounds 4-8-4	Field Planted	133.3	59.5	56.4	57.7	94.8	58.6
Manure, 500 pounds 4-8-4 150 pounds $NaNO_3$ side dressing	Veneer Bands	169.5	141.4	169.5	45.4	169.5	93.4
Manure, 500 pounds 4-8-4 150 pounds $NaNO_3$ side dressing	Field Planted	125.2	84.8	87.7	60.6	106.4	72.7
Rye and 150 pounds KCl, 450 A. P. *250 tankage under hills 100 pounds $NaNO_3$, 100 pounds Fish	Veneer Bands	248.5	204.5	185.0	96.8	216.7	150.6
Rye and 150 pounds KCl, 450 A. P. *250 tankage under hills 100 pounds $NaNO_3$, 100 pounds Fish	Field Planted	30.5	42.9	36.0	51.3	33.2	47.1

*Plot 9.

Influence of Amounts and Time of Applying Nitrate of Soda to Peppers, Sweet Corn, and Tomatoes

Project 25

This series of fertilizer treatments started in the spring of 1923 was continued without modification in 1925. These plots are located at New Brunswick and are 1/50 acre in extent, except the pepper plots, which are 1/100 of an acre.

The varieties used in this experiment are Ruby King Pepper, Howling Mob Sweet Corn and Greater Baltimore Tomato.

The results secured in 1925 are given in tables 7, 8 and 9

TABLE 7

Influence of Amounts and Time of Applying Nitrate of Soda on Ruby King Peppers—1925

Treatments			YIELDS OF FRUITS PER ACRE					
			Series A		Series B		Average	
			tons	*count*	*tons*	*count*	*tons*	*count*
	CHECK		3.125	43,550	2.744	38,350	2.934	40,950
A.P.	*Potash*	*Nitrate*						
600	200	100	4.909	68,100	4.115	62,800	4.512	65,450
600	200	50*	5.28	58,550	4.9	62,550	5.09	60,550
300*	100*	50*	4.7	61,150	4.842	66,950	4.771	64,050
600	200	†	4.883	63,000	4.733	63,800	4.808	63,400
600	200	150*	5.597	79,250	5.25	87,000	5.423	83,120

*Applied 3 weeks after planting.
†100 pounds nitrate 3 weeks after planting.

TABLE 8

Influence of Amounts and Time of Applying Nitrate of Soda on Howling Mob Sweet Corn—New Brunswick, 1925

Treatment			YIELDS IN EARS PER ACRE					
			Series A		Series B		Average	
			Firsts	Seconds	Firsts	Seconds	Firsts	Seconds
	CHECK		3750	5450	6500	4300	5125	4875
A.P.	*Potash*	*Nitrate*						
600	200	100	7250	4050	8000	3850	7625	3950
600	200	200	8150	4500	11150	2600	9650	3550
600	200	300	8900	3800	9600	4400	9250	4100
600	200	50*	6900	4400	7050	5300	6975	4850
300*	100*	50*	10000	2500	6750	6150	8375	4325
600	200	†	7500	4150	5850	6000	6675	5075
600	200	150*	10100	3350	8650	4400	9375	3875
	CHECK		5250	4950	4700	6950	4975	5950

*Applied 3 weeks after planting.
†100 pounds nitrate 3 weeks after planting.

TABLE 9

Influence of Amounts and Time of Applying Nitrate of Soda on Greater Baltimore Tomatoes—New Brunswick, 1925

Treatment			YIELD PER ACRE		
			Series A	Series B	Average
			tons	*tons*	*tons*
	CHECK		8.24	5.77	7.00
A.P.	*Potash*	*Nitrate*			
600	200	100	11.33	15.15	13.24
600	200	200	14.96	20.84	17.9
600	200	300	16.78	17.09	16.93
600	200	50*	14.31	12.19	13.25
300*	100*	50*	18.17	10.98	14.57
600	200	†	11.77	11.72	11.74
600	200	150*	17.23	15.60	16.41
	CHECK		7.09	9.33	8.21

*Applied 3 weeks after planting.
†100 pounds nitrate 3 weeks after planting.

The Effect of the Size of Asparagus Roots Upon the Development and Yields of the Plants

H. F. HUBER

An experiment was started at the College Farm in the spring of 1924 to compare the value for planting of asparagus roots of different sizes. The experiment was enlarged in 1925, and as the report of the work done in 1924 has not yet been published, it is included here with the records of 1925.

In 1924 three grades of roots, firsts, seconds and culls, were selected from a lot of asparagus roots grown at the College Farm. The variety was the Atlock Farms Strain of Palmetto. Two hundred roots of each grade were planted in a row and spaced 18 inches apart. The three rows were spaced 5 feet apart. Measurements were taken of the roots before planting, and the tops were measured at the end of the growing season. The results appear in table 1, together with the measurements made in 1925.

The experiment was enlarged in 1925 by making a similar planting of 3 grades of roots of Washington asparagus adjacent to the plot planted in 1924. The results are also shown in table 1. Because of an error in the spacing of the roots of the second grade the results cannot be included.

The experiment will be continued through the normal productive period of an asparagus bed in order to determine the effect on production. No definite conclusions can be drawn until after several commercial cuttings have been made. However, the results indicate that in the early growth of asparagus roots there is a greater difference between roots of the second and cull grade than between first and second grades.

Table 1

Growth Made by Asparagus Roots of Different Grades the First and Second Seasons—New Brunswick

Palmetto 1924		Date	Firsts	Seconds	Culls
Weight of Root	*ounces*	4-1-24	2.56	1.36	.56
Number of Storage Roots		4-1-24	26.9	19.5	13.1
Average Length of Storage Root	*inches*	4-1-24	6.3	5.7	4.9
Number of Stalks per Plant		10-7-24	4.2	4.6	3.5
Average Length of Stalk	*inches*	10-7-24	31.9	33.2	25.9
Weight of Stalks per Plant	*ounces*	10-9-24	4.1	4.0	2.1
Palmetto 1925					
Number of Stalks per Plant		10-1-25	5.7	6.9	4.5
Average Length of Stalk	*inches*	10-1-25	48.3	39.7	33.4
Weight of Stalks per Plant	*ounces*	10-16-25	13.3	12.1	8.9
Plants Remaining out of 200		10-7-25	196	199	181
Washington 1925					
Weight of Root	*ounces*	4-17-25	2.1		0.7
Number of Storage Roots		4-17-25	30.8		17.6
Average Length of Storage Root	*inches*	4-17-25	7.5		6.1
Number of Stalks per Plant		10-7-25	5.7		5.5
Average Length of Stalk	*inches*	10-7-25	31.8		30.7
Weight of Stalks per Plant	*ounces*	10-15-25	6.1		5.7

Studies of the Growth Responses of Horticultural Plants, Associated Chemical Changes in Foods, and the Utilization of Nutrients

G. T. Nightingale and L. G. Schermerhorn

About 7,000 acres of asparagus are grown in New Jersey yet there is much disagreement as to the time for application of nitrates. Some maintain that asparagus plants may not be able to use nitrates before green tops are present.

During the winter and spring of 1926, asparagus plants were grown in the greenhouse in quartz sand culture and in solution culture. Part of the plants were subjected to continuous darkness and others to the seasonal light conditions as they occurred in the greenhouse. The plants in the light and some of them in the dark were given a complete nutrient solution containing nitrates, while others grown in the dark were given a nutrient solution containing no nitrogen.

It has been found by several careful trials that an aliquot portion of an asparagus root crown of about ten per cent may be removed for analysis while the remaining 90 per cent may be used for experimental purposes. Quantitative analyses have also shown that the 90 per cent and the 10 per cent factions are practically identical with respect to their percentage composition. Accordingly, the composition of asparagus crowns at the beginning of an experiment may be computed.

On an absolute amount basis, quantitative data have been secured which would indicate that asparagus may not only take in nitrates in the dark, but that as long as there is a carbohydrate supply present, plants seem able to build up nitrates to higher forms of nitrogen, with an accompanying increase in yield of spears as compared to unnitrated series grown in the dark.

The assimilation of nitrates seemed to occur as rapidly in the dark as in the light. Microchemical tests of plus nitrate series have consistently shown an abundance of nitrates in the fibrous feeding roots, with none at all, or extremely small amounts of nitrates, in the storage roots. The rapidly growing spears in the dark contained no nitrates, except occasional traces in the lower parts of the spears. There were no nitrates in the spears that were grown in the light except when vegetative extension was slowed up as by approaching maturity or cold weather, at which times there was an accumulation of nitrates in the tips and lower parts of the spears.

At no time were nitrates found in any part of the minus nitrogen series. As would be expected, the growth of the minus nitrogen series was associated with a decrease in protein and an increase in nitrate-free soluble nitrogen, while in the plus nitrate series the growth was associated not only with a loss of protein, but apparently as well with synthesis of nitrates to other forms of nitrogen. In the dissection of the nitrate-free soluble nitrogen fractions, proteose, polypeptide, amide, amino, and humin nitrogen fractions were determined. Data and further discussion of these fractions will be given in another report.

Analysis of the roots of the several series show, as would be expected, that there was a considerable loss of carbohydrates associated with growth of spears. It would seem particularly significant that there was a much larger loss of carbohydrates in the plus nitrogen dark series than in the minus nitrogen dark series. Presumably, the larger loss of carbohydrates in the plus nitrogen dark was due to the fact that the carbohydrates were used in the assimilation of nitrates.

The carbohydrate fractions determined include total sugars, reducing sugars, sucrose, polysaccharides,[1] hemicellulose, and fat. These data and further details concerning them will be given at another time.

The experimental conditions obtaining, and the work of Lipman[2] and others, would seem to minimize the possibility of bacterial action affecting the results secured. In addition, the following observations would seem significant. Root crowns in plus nitrate solution culture grown in the dark and with tops removed daily had an abundance of nitrates in the fibrous absorbing roots and none in the storage roots. These crowns, after thorough washing, were placed in distilled water, and frequent observations of all parts of many crowns showed that nitrates disappeared in about 2 hours at 20°C. Like roots at a temperature of 10° C. still contained traces of nitrates in the fibrous roots after about 12 hours. That there was no loss of nitrogen from the roots was indicated by macrochemical analysis of the residual distilled water for total nitrogen, ammonia, and nitrate nitrogen.

---

[1] Tauret, George 1909 The asparagus plant contains no starch, but contains an inulin-like polysaccharide, "asparagose," which upon hydrolysis yields 93 per cent levulose and 7 per cent glucose. *Compt. Rend.* 149:48-51.

[2] Lipman, C. B., and Taylor, J. K. 1924. Do Green Plants have the Power of Fixing Elementary Nitrogen from the Atmosphere? *Jour. Franklin Inst.* 198:475-507.

Report of the Department of Plant Pathology

WILLIAM H. MARTIN

The work of the department of plant pathology covered a wide range of activities during the past year. The more important of these follow:

(1) Most of the time of the various members of the department was devoted to work on the research projects. Although no new projects were undertaken during the year, a number of changes were made in the old ones, a special effort being made to reduce their number by combining them whenever possible.

A brief statement is given of the year's work on some of the projects in the following pages of this report. In other cases, the data have been prepared for publication elsewhere and no mention need be made of them here.

(2) During the year 6 technical and 38 popular articles were published by members of the department. In addition, a series of one-page leaflets on the common diseases of the important agricultural crops was started. Eight of these were prepared and a number of others planned.

(3) The monthly publication of "Plant Disease Notes" was continued. This is sent to all extension workers and serves as an excellent medium whereby they may be kept informed of new developments in plant pathology.

(4) Through the publication "Hints to Potato Growers" the department was able to keep before the growers the recent advances made in the knowledge of potato diseases and their control.

(5) As in the past, the department cooperated with the State Department of Agriculture in the certification of white and sweet potatoes, corn and tomatoes. Considerable time was spent with the growers of seed potatoes in developing methods of improving their seed.

(6) A number of additions were made to the Herbarium and the acquisition of a new room has greatly facilitated the teaching work of the department.

(7) The department has engaged in numerous extension activities. Members of the department attended 30 meetings and addressed approximately 2,500 persons.

At the request of the county agents, a large number of personal visits were made to farms to diagnose plant diseases and make recommendations for their control.

The members of the department cooperated with the county agents in conducting seed source and variety test plots, seed-potato disinfection demonstrations, potato spraying, seedbed treatment and numerous other phases of plant disease control.

During the year 13,000 pieces of mail consisting of letters, bulletins and circulars were sent out from the department.

Needs of the Department

The department was fortunate in securing some very excellent equipment during the past year. This consisted of new constant-temperature and paraffin ovens, as well as cabinets for class material. The addition of this new material will facilitate both the research and the teaching. We are still in need of constant-temperature ovens for the study of the influence of temperature on plant pathogenes, and particularly we should have apparatus for the regulation of soil and atmospheric temperatures in the greenhouse.

NEW JERSEY PLANT DISEASES, 1925

WILLIAM H. MARTIN

The following report is a statement of the occurrence of plant diseases, together with observations on their prevalence and the losses they caused in 1925. The observations were made by the members of the department of plant pathology, and, while they are by no means complete for all plants, they may be considered fairly comprehensive for the diseases of economic importance on the agricultural crops. In view of the close relationships of some of these diseases with atmospheric conditions, the graph in figure 1 is included to show the deviations from average temperature and precipitation in the different months.[1]

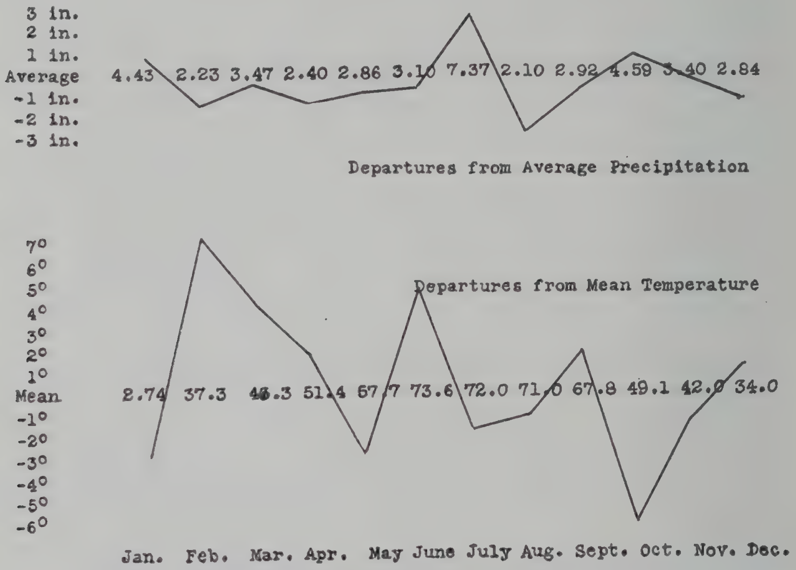


FIG. 1. DEVIATIONS FROM AVERAGE TEMPERATURE AND PRECIPITATION IN 1925

The year 1925 was warm and dry in New Jersey, the mean temperature being 0.4° F. above normal and the average precipitation 4.39 inches below normal. In June the mean temperature was 73.6° F., over 5° above normal; this, coupled with the fact that the rainfall was slightly deficient, resulted in extremely unfavorable growing conditions. The potato crop was seriously injured and, while mosaic was apparently much less severe than in 1924 and no late blight and only a trace of early blight was observed, certain other diseases were much more prevalent. This was especially true of hopper-burn, leaf roll and rhizoctonia. On the lighter soil types in Burlington County, rhizoctonia cankers were very abundant, and in a number of instances the crop was practically ruined as the result of the presence of this disease. Leaf hoppers were present in large numbers and caused serious yield reductions in all parts of the state.

---

[1] This information was taken from "Climatological Data" prepared by G. Harold Noyes of the State Department of Agriculture, Weather Bureau, Trenton, N. J.

The deficiencies in rainfall in March, April and May no doubt accounted for the fact that apple scab and black rot infections on the leaves of the apple were much less severe than in 1924; apple scab being almost entirely absent in orchards where the previous year nearly every fruit was attacked. The blossom blight form of peach brown rot was severe in some orchards; following this form of the injury, there was little more trouble experienced until late in the season when fruit rot appeared in poorly sprayed or poorly dusted orchards.

Sweet potato scurf and stem rot were especially severe. Stem rot was first observed on June 5 and was soon found in all of the sweet-potato growing sections, the losses for the state amounting to 30 per cent of the crop. Low temperatures in July and August with an excess of rainfall in July resulted in an unusual development of mildews on weeds, ornamental and crop plants.

The estimated losses from plant diseases to field crops, including the potato, tomato and sweet potato, were 18.0, 18.5, and 35.2 per cent, respectively. In the case of the potato and tomato these were only slightly higher than in 1924, while the sweet potato losses were over twice as great. In the case of the fruit crops the disease losses were estimated as follows: apple 8.0 per cent, peach 8.0 per cent, bean 5.5 per cent, cherry 4.5 per cent, and plum 5.0 per cent. In every instance this was considerably under the estimated losses for last year. In the cereal crops the losses were estimated at 2 per cent for wheat, 2 per cent for rye, 2.5 per cent for oats, and 4 per cent for corn.

Diseases Arranged by Hosts

Alfalfa

Leaf Spot (*Pseudopeziza medicaginis* [Lib.] Sacc.). Less than usual, but generally distributed.

Bacterial Blight (*Bacterium sp.*) Found in restricted areas on the College Farm. First report for this disease.

Apple

Cedar Rust (*Gymnosporangium juniperi-virginianae* Schw.). Less than usual.

Blotch (*Phyllosticta solitaria* E. & E.) First observed June 15 at Holmdel, generally prevalent and severe in some orchards, particularly on the Smith Cider variety. Loss for state estimated at 0.75 per cent. While the infection on the fruit was approximately the same as in 1924 there was a marked decrease in the amount of wood infection, due probably to the drought conditions. Spraying with bordeaux mixture gave 86.3 per cent clean fruit as compared with 11.5 per cent on unsprayed trees and 48.1 per cent on those sprayed with concentrated lime-sulfur, 1-40.

BITTER PIT (cause unknown). Observed on York Imperial, Northwestern Greening, Baldwin, Grimes and Delicious.

SCAB (*Venturia inaequalis* [Cke.] Wint.). First observed May 15 on leaves at Vineland. Less than usual, being severe only in unsprayed or poorly sprayed orchards. Reported on Winesap, Rome Beauty, Paragon, Star, Smith Cider. In one orchard 35 per cent of the fruit affected on Winesap as compared with trace on Stayman. Losses for the state estimated at 4.0 per cent. At Moorestown, first discharge of ascospores took place on April 25 and the last on June 10. Heaviest spore discharge occurred between April 25 and May 10. In this orchard the pink application was made on April 16.

WATER CORE (cause unknown). Several reports of this trouble on Smith Cider.

FRUIT SPOT (*Phoma pomi* Passer). Much less than usual. In most cases the trouble did not show up until after the fruit was placed in storage. Time of infection studies indicated infection to take place early in the summer. Fruits bagged as early as May 21 showed some infection. Those bagged August 10 showed 100 per cent infection. The use of Dry Mix following the regular spray schedule gave 16.9 per cent clean fruit, 56.6 per cent with 1 to 5 spots and 26.5 per cent with more than 5 spots. Unsprayed trees showed 1.6 per cent clean fruit, 11.3 per cent with less than 5 and 87.1 per cent with more than 5 spots.

BLOSSOM END ROT (*Alternaria* sp.). Very severe in several orchards. In one orchard the Pippin showed 20 per cent fruit infected. Observed on Pippin, Ben Davis, Jonathan, Wealthy, Gravenstein and Winter Banana. A species of *Alternaria* was isolated and successful inoculations made. It is possible that the initial infection followed spray injury.

BITTER ROT (*Glomerella cingulata* Stonem. Sp. and von S.). Of minor importance.

BLACK ROT (*Physalospora malorum* [Pk.] Shear). Less abundant than usual. First observed on leaves on May 22. Very little rotting of the fruit observed.

SUPERFICIAL BARK CANKER (*Myxosporium corticolum* Edg.). Reported from all parts of the state. Found on Rome Beauty, McIntosh, Twenty Ounce, Duchess, and Pippin.

CROWN GALL (*Bacterium tumefaciens* E. F. S. and Town.). Present but no unusual development of the disease observed.

FIRE BLIGHT (*Bacillus amylovorus* [Burr.] Trev.). First observed on June 2. Less than usual. Only a trace in orchards where previously it had been severe.

POWDERY MILDEW (*Podosphaera leucotricha* [E. & E.] Salm.). Very severe on Rome Beauty in one orchard in Burlington County.

SPRAY INJURY. Generally distributed and very severe in some orchards. Observed in orchards sprayed with bordeaux mixture, dry-mix sulfur-lime, sulfur-lead-lime dust, and concentrated lime-sulfur. Calyx injury very common in some orchards. Severe leaf injury in others.

SUN SCALD (high temperatures and drought). More prevalent than last year.

SOOTY BLOTCH AND FLY SPECK (*Leptothyrium pomi* [Mont. and Fr.] Sacc.). Reported from North Jersey where it is much more abundant than in the rest of the state due largely to the fact that the late summer sprays are frequently omitted.

MEASLES (cause undetermined). Reported from Cape May County.

JONATHAN SPOT (cause undetermined). Present but not serious.

Asparagus

RUST (*Puccinia asparagi* D. C.). First reported on June 16. Less abundant than usual.

WILT (*Fusarium* sp.). Several reports.

Aster

WILT (*Fusarium* sp.). Several reports.

YELLOWS (cause undetermined). Generally prevalent.

Bean

POD BLIGHT (*Diaporthe phaseolorum* [Cke. and Ell.] Sacc.). Reported, but not serious, on Limas.

RUST (*Uromyces appendiculatus* [Pers.] Lk.). First reported on June 18, very severe in some plantings.

MOSAIC (cause undetermined). First reported August 28. Generally prevalent but unimportant.

ANTHRACNOSE (*Colletotrichum lindemuthianum* [Sacc. and Magn.] Br. and Cav.) Present but caused little damage.

Beet

LEAF SPOT (*Cercospora beticola* Sacc.). First reported June 14. Generally prevalent but not severe.

SCAB (*Actinomyces scabies* [Thaxt.] Gues). More abundant than usual, very severe in some plantings.

Blackberry

ANTHRACNOSE (*Plectodiscella veneta* [Speg.] Burk.). Commonly found and very severe in some plantings.

ORANGE RUST (*Gymnoconia interstitialis* [Schlecht] Lagerh.). First observed on April 15 in Middlesex County. Generally distributed but not severe in commercial plantings.

LEAF SPOT (*Septoria Rubi* Westd.). Observed on September 12 at New Brunswick. Not of economic importance this season.

MOSAIC (cause undetermined). Reported from all parts of the state. Owing to the drought conditions the typical symptoms did not appear until late in the summer.

LEAL CURL (cause undetermined). Reported from all parts of the state.

Box

LEAF SPOT (*Macrophoma Candollii* [B. and Br.] B. and V.). Noted in Monmouth County.

Cabbage

CLUB ROOT (*Plasmodiophora brassicae* Wor.). Severe in seedbeds.

BLACK LEG (*Phoma lingam* [Tode] Desm.). Less abundant than in 1925, but very severe on some farms. In one field plants of the Low Flat Dutch and All Season varieties from one seedbed were clean while plants from another seedbed were heavily infected.

YELLOWS (*Fusarium conglutinans* Woll.). One report from Camden County.

LEAF SPOT (*Alternaria brassicae* [Berk.] Sacc.). Noted but not severe. Largely confined to the outer leaves.

DOWNY MILDEW (*Peronospora parasitica* [Pers.] De Bary). Observed on seedlings in the coldframe in North Jersey. Every plant attacked. Spraying with bordeaux mixture (3-4-50) checked the development of disease.

BLACK ROT (*Bacterium campestre* [Pam.] E. F. S.) Present as usual, but not the cause of serious losses.

Cantaloupe

LEAF BLIGHT (*Macrosporium cucumerinum* E. & E.). Less than usual, but common in some sections of South Jersey.

MOSAIC (cause unknown). Very prevalent throughout South Jersey.

ANTHRACNOSE (*Colletotrichum lagenarium* [Pass] E. & H.) Reported on leaves, not severe on the fruit.

Carnation

RUST (*Uromyces caryophyllinus* [Schrank] Wint.). Severe in some greenhouses.

Catalpa

LEAF SPOT (*Phyllosticta catalpae* E. & M.). One report from Monmouth County.

Cauliflower

LEAF SPOT (*Alternaria brassicae* [Berk.] Sacc.). One report, very severe.

Celery

EARLY BLIGHT (*Cercospora apii* Fr.). Less prevalent than usual.

LATE BLIGHT (*Septoria apii* Rostr.). Less than usual, but very common in North Jersey. Little damage resulted, however, largely as the result of its late appearance.

YELLOWS (*Fusarium* sp.). Reported in the seedbed in North Jersey.

Cherry

BROWN ROT (*Sclerotinia fructicola* [Wint.] Rehm). Generally distributed, but much less severe than in 1925. Losses for state estimated at 4 per cent.

LEAF SPOT (*Coccomyces hiemalis* Higgins). Generally distributed, but much less prevalent than in 1925 when many orchards were defoliated by the time the fruit was harvested. This year the disease was not noted until July 17 and was not commonly prevalent until after August 15.

POWDERY MILDEW (*Podosphaera oxyacanthae* [D.C.] De Bary). More abundant than usual. First noted on August 29.

BLACK KNOT (*Plowrightia morbosa* [Schw.] Sacc.). Generally distributed, but not serious.

Chestnut

BLIGHT (*Endothia parasitica* [Murr.] A & A.). Common.

Chrysanthemum

LEAF SPOT (*Septoria chrysanthemella* Cav.). One report from Bergen County.

MOSAIC (cause unknown). Less prevalent than usual.

WILT (*Verticillium albo-atrum* R. & B.). Reported from all parts of the state.

YELLOWS (cause unknown). One report from Middlesex County.

Clover

RUST (*Uromyces* sp.). One report from Mount Holly.

POWDERY MILDEW (*Erysiphe polygoni* D. C.). First reported May 15 from Burlington County. Generally prevalent, but less abundant than usual.

ANTHRACOSOSE (*Gloeosporium caulivorum* L. Kirch.). Not previously reported. Observed May 15 on the College Farm in a clover variety test. Present on Italian Red Clover, none on the American varieties.

MOSAIC (cause unknown). Generally prevalent, but of little importance.

Corn

ROOT AND STALK ROT (*Fusarium* sp. and *Gibberella* sp.). Less prevalent than usual.

SMUT (*Ustilago zeae* [Beck.] Ung.). Generally distributed and more abundant than usual.

PINK EAR ROT (*Fusarium moniliforme* Sheld.). Losses less than in 1925.

Cucumber

WILT (*Bacillus tracheiphilus* E. F. S.) Generally prevalent, but most abundant in South Jersey where it caused serious losses in some fields.

MOSAIC (cause undetermined). Generally distributed.

Currant

ANTHRACNOSE (*Pseudopeziza Ribis* [Kleb.]). Much less prevalent than in 1924. Cause of little loss.

LEAF SPOT (*Mycosphaerella grossulariae* [Fr.] Lind.). Noted, but not serious.

Dahlia

MOSAIC (cause unknown). Generally distributed, severe in some plantings.

BUD-ROT (*Botrytis* sp.). Noted in Middlesex County.

Dandelion

RUST (*Puccinia taraxaci* [Ruben] Plowr.). Very abundant in all parts of the state.

Mildew (*Sphaerotheca humuli fuliginia* [Schl.] Sal.). Severe on commercial plantings of dandelion in Northern Jersey.

Eggplant

Wilt (*Verticillium albo-atrum* R. & B.). Generally reported. Less severe where green manures were plowed under or sulfur applications made.

Fruit Rot (*Phomopsis vexans* [Sacc & Syd.] Harter). Less abundant than usual, but severe in some plantings. Dusting with copper-lime dust after fruit rot had started failed to check the disease.

Gray Mold Rot (*Botrytis cinerea* (Auct.). Two reports. Cause of little damage.

Bacterial Soft Rot (*Bacillus carotovorus* L. R. J.). Very severe on Long Purple in one field where eggplants had been grown for 3 years in succession.

Evening Primrose

Mildew (*Erysiphe communis* [Wallr.] Fr.). One report on August 14 from Middlesex County.

Gladiolus

Hard Rot (*Septoria gladioli* Pass.). Less than usual, but severe in some plantings. Soaking 6 hours in the organic mercury compounds greatly reduced the severity of this disease.

Golden Rod

Tar Spot (*Rhytisma solidaginis* Schw.). Generally distributed.

Mildew (*Oidium erysiphoides* Fr.) First reported August 6 from Middlesex County. More abundant than usual.

Gooseberry

Anthracnose (*Pseudopeziza Ribis* Kleb.). Less than usual.

Leaf Spot (*Septoria Ribis* Desm.). Not important.

Grape

Downy Mildew (*Plasmopara viticola* [B. & C.] Berl. and de Toni). Severe in some vineyards.

Black Rot (*Guignardia bidwellii* [Ell.] V. & R.). Less prevalent than usual; of no importance on sprayed vines.

Hawthorne

Rust (*Gymnosporangium germinale* [Schw.] Kern.). One report from Monmouth County.

Hollyhock

Rust (*Puccinia hibisciata* [Schw.] Kell.). Less prevalent than usual.

Horse-Chestnut

Leaf Blotch (*Guignardia aesculi* [Peck] V. B. Stewart). Less than usual but severe in some localities.

Horse Radish

Root Rot (Bacterial). Reported from North Jersey, but not severe.

Black Mold (*Alternaria herculea* [E. & M.] J. A. E.) Present, but not severe.

Indigo

Mildew (*Erysiphe communis* [Wallr.] Fr.). One report from Middlesex County.

Laurel

Leaf Spot (*Cercospora kalmiae* E. & E.). One report from Middlesex County.

Lilac

Powdery Mildew (*Microsphaera alni* [Wallr.] Wint.). Less than in 1925 and not common until late in the season.

Lettuce

Drop (*Sclerotinia Minor* Jagger—*Sclerotinia libertiana* Fuckel). Very severe in some fields in South Jersey. Appeared late in the summer.

Gray Mold (*Botrytis cinerea* Auct.) Severe in some coldframes in North Jersey.

Tip Burn (cause unknown). More abundant than usual. Very severe in some of the southern counties; in one field of 10 acres, every plant was ruined.

Root Knot (Nematodes). One report from Bergen County, 5 to 10 per cent infection in one field.

Lima Bean

Downy Mildew (*Phytophthora phaseoli* Thax.). Less abundant than usual. First noted on September 2 in Mercer County. Because of its late appearance it caused little loss.

Maple

Leaf Spot (*Phyllosticta acericola* C. & E.). One report from Monmouth County.

May Apple

Rust (*Puccinia podophyllis* Schw.). One report from Somerset County.

Morning Glory

White Rust (*Albugo ipomoea-panduranae* Schw. Swing.). One report from Middlesex County.

Leaf Spot (*Cercospora alabamensis* Atk.). One report from Middlesex County.

Oak

Blight (*Gloeosporium nervisequum* [Fck.] Sacc.). Less than in 1925, but more abundant than usual. First observed May 15 from Gloucester County.

Oats

Crown Rust (*Puccinia coronata* Cda.). Generally distributed, but not the cause of serious losses.

Smut (*Ustilago avenae* [Pers.] Jens.). Severe in some localities. Loss for state estimated at 2 per cent.

Okra

Wilt (*Verticillium albo-atrum* R. & B.). This disease was again very severe this year. A variety test conducted on a wilt infested soil showed none of the varieties included to be resistant.

Parsley

Late Blight (*Septoria petroselini* Desm.). One report from Sussex County.

Parsnip

Leaf Blight (*Cercospora apii pastinacae* Farl.). One report from Monmouth County.

Pea

Seed and Seedling Rot (*Pythium* sp.). Less prevalent than usual.

Root Rot (*Aphanomyces euteiches* Drechs.). Less than usual, but present in many of the fields. Some fields showed 100 per cent infection. Losses for the state estimated at 2 per cent. The disease was first noted on May 15 and did the most damage between June 1 and 15. Canada field peas proved to be very susceptible and Winter Vetch slightly susceptible in greenhouse tests.

Blight (*Ascochyta pisi* Lib.). Leaf and pod blight very rare this year, but the root rot stage was unusually severe. Infection probably resulted from planting diseased seed.

Mosaic (cause unknown). More abundant than usual. Apparently increasing yearly. As many as 60 per cent of the plants were affected in one small planting. The Alaska variety apparently less affected.

Peach

Mottle Leaf (cause unknown). Reported from Monmouth and Cape May counties.

BACTERIAL SPOT (*Bacterium pruni* E. F. S.) Generally distributed throughout South Jersey. Less prevalent than in 1925, but common in some orchards. Most abundant on the Hale variety.

LEAF CURL (*Exoascus deformans* [Berk.] Fckl.). Less important than usual. First reported on May 15 from Cumberland County.

BROWN ROT (*Sclerotinia fructicola* [Wint.] Rehm.). Less than in 1925, but slightly more than usual. Severe blossom blight form of the injury in Burlington County. The disease was also the cause of serious fruit rotting in some orchards. Losses from the state estimated at 4 per cent.

SCAB (*Cladosporium carpophilum* (Thuem). Less important than usual. Very little found in orchards dusted with sulfur lime dust.

LITTLE PEACH (cause unknown). About the same as usual.

YELLOWS (cause unknown). No serious outbreak, but common in the vicinity of Vineland.

SPRAY INJURY (excess of arsenical). Much less abundant than in 1925 due to the fact that smaller amounts of arsenical were used. Where 1 pound of arsenate of lead in dry-mix was used no burning resulted; where this amount was increased to 1½ pounds, injury resulted.

Pear

BLIGHT (*Bacillus amylovorus* [Burr.] Trev.). Generally distributed, but less prevalent than usual.

LEAF BLIGHT (*Fabraea maculata* [Lév.] Atk.). Less prevalent than usual.

SCAB (*Venturia pyrina* Aderh.). Unimportant.

Pepper

BLACK MOLD (*Alternaria* sp.) One report from Gloucester County. Not severe.

MOSAIC (cause unknown). Generally prevalent, but not severe.

Plantain

MILDEW (*Sphaerotheca castagnei* Lév.). More abundant than usual.

SLIME MOLD (*Physarum cinereum* [Bat.] Pers.) One report on August 8 from Gloucester County.

Plum

BROWN ROT (*Sclerotinia fructicola* [Wint.] Rehm.). First report August 10 from Middlesex County. Prevalent, but less severe than last year.

BLACK KNOT (*Plowrightia morbosa* [Schw.] Sacc.). Several reports from different parts of the state.

Potato

LATE BLIGHT (*Phytophthora infestans* [Mont.] De B.). Seed potatoes showing the typical tuber rot were planted, but the disease was not observed on either the early or the late crop.

EARLY BLIGHT (*Alternaria solani* [E. & M.] J. & G.) Less than usual, much less than in 1925. Largely confined to South Jersey. First report July 1 from Cumberland County. Losses very slight.

HOPPER BURN (Leaf Hopper). More prevalent than usual. Present in all parts of the state. Some fields observed where 95 per cent of the leaves were killed by this insect. Losses for the state estimated at 5 per cent. Hopper-burn was readily controlled by spraying with bordeaux mixture.

SPINDLE TUBER (cause unknown). General throughout central and southern Jersey. Loss for the state 1.5 per cent. The planting of certified seed greatly reduces the loss from this disease.

LEAF ROLL (cause unknown). Generally distributed throughout the state. In some fields 90 per cent of the plants were affected. Losses for the state estimated at 6 per cent.

MOSAIC (cause unknown). Much less prevalent than usual. On the early crop the symptoms were obscured due to the drought conditions. On the late crop the usual amount was observed.

STEM ROT, etc. (*Corticium vagum* B. & C.). More than usual. Stem canker form very severe on light sandy soils in Gloucester, Burlington and Camden counties. In central and southern New Jersey, on the heavier soils, there was no more than usual. In many cases the plants were attacked before coming through the ground; in some fields 75 per cent of the plants were affected and the crop was plowed under. Loss for the state estimated at 3 per cent. The perfect stage of the organism was found on stems collected at Robbinsville in June during drought conditions.

Common Scab (*Actinomyces scabies* [Thax.] Gues). More than in 1925. In some fields 20 per cent of the crop was unsalable. Estimated loss for the state 4 per cent.

Black Leg (*Bacillus atrosepticus* van Hall). Less than usual—only a few infected plants observed. First report on June 8 from Mercer County. Losses slight.

Wilt (*Fusarium oxysporum* Schl.). Less than in 1925. Losses small.

Silvery Scurf (*Spondylocladium atrovirens* Harz.). Rather general on the late crop in South Jersey.

Prune

Black Knot (*Plowrightia morbosa* [Schw.] Sacc.) One report from Bergen County.

Quince

Leaf Blight (*Fabraea maculata* [Lev.] Atk.). Of little importance this year.

Fire Blight (*Bacillus amylovorus* [Burr.] Trev.) Present, but not severe.

Crown Gall (*Bacterium tumefaciens* [E. F. S.] Town.). One report from Union County.

Ragweed

Mildew (*Oidium ambrosiae* Thuem). One report from Middlesex County.

Rubber Plant

Leaf Spot (*Leptostromella elasticae* E. & E.) One report from Essex County.

Rutabaga

Scab (*Actinomyces scabies* Thax.). One report from Monmouth County.

Raspberry

Anthracnose (*Plectodiscella veneta* [Speg.] Burk.). Generally distributed, very severe in some parts of South Jersey. First observed May 19 in Atlantic County.

Mosaic (cause undetermined). Less prevalent than usual, probably due to the fact that the symptoms were masked by the high summer temperature.

Leaf Spot (*Septoria Rubi* Westd.). Present, but comparatively unimportant. First observed in Middlesex County on August 1.

Rhododendron

Leaf Spot (*Pestalozzia guepini* Desm.). Severe in plantings in South Jersey. Also reported from Hudson County. Also severe as a graft canker.

Rhubarb

Leaf Spot (*Ascochyta Rhei* E. & E.). Generally present, but not severe.

Rose

Root Gall (*Nematodes*). Heavy infection on roots of plants from nursery in Monmouth County.

Black Spot (*Actinonema Rosae* [Lib.] Fr.). Less than usual.

Powdery Mildew (*Oidium leucoconium* Desm.). More abundant than usual.

Cane Blight (*Coniothyrium fuckelii* Sacc.). One report from Passaic County. Severe in some nurseries in the vicinity of Red Bank.

Crown Gall (*Bacterium tumefaciens* [E. F. S.] Town.). General, but not severe.

Rye

Leaf Rust (*Puccinia dispersa* Eriks). Prevalent, but of little importance.

Snapdragon

Wilt (*Verticillium* sp.). Two reports from Mercer and Morris counties.

Rust (*Puccinia antirrhini* D. & H.) One report from Middlesex County.

Spinach

Downy Mildew (*Peronospora effusa* [Grev] Rabenh.). Less than in 1925, but severe in some fields.

Blight (cause undetermined). Severe in some plantings in North Jersey. Virginia Savory very resistant.

Squash

Mildew (*Erysiphe polygoni* D. C.) Prevalent in all parts of the state. Of minor importance.

Strawberry

Leaf Spot (*Mycosphaerella fragariae* [T. & S.] Lin.). Less than usual, but prevalent in all parts of the state.

Black Root (cause undetermined). Observed in all parts of the state.

Sweet Pea

Root Rot (*Thielavia basicola* [B. & Br.] Zopf.). One report from Essex County.

Crown Gall (*Bacterium tumefaciens* E. F. S. & Town.). This is the first report for this disease. Reported for two years in a greenhouse at Clinton. Fasciations produced on the stems near the surface of the soil.

Powdery Mildew (*Microsphaera alni* [Wal.] Wint.). One report from Middlesex County.

Sweet Clover

Leaf Spot (*Ascochyta meliloti* [Trel.] Davis). One report from Middlesex County.

Sweet Potato

Black Rot (*Sphaeronema fimbriatum* [E. & H.] Sacc.). About the same as in the average year, but comparatively unimportant. This disease is being largely eliminated through seed selection and clean plantbeds. Losses for the state estimated at 2 per cent.

Soil Rot (*Cystospora batata* [Ells. & Hals.] Elliott). More abundant than usual. First observed on May 28. Found on 80 per cent of the fields examined. In some the losses were negligible while in others the crop was a complete failure. Especially severe where alfalfa was planted in the rotation and the soil heavily limed. Losses estimated at 5 per cent.

Scurf (*Monilochaetes infuscans* E. & H.). Present in 50 per cent of the fields examined, but the percentage of infection was much less than in previous years.

Leaf Spot (*Septoria bataticola* Taub.). Observed in only a few fields and of little importance.

Stem Rot (*Fusarium batatatis* Woll. & *E. hyperoxysporum* Woll.). Losses greater than usual. First observed on June 5. Losses for state estimated at 30 per cent. The Red Brazil, Yellow Yam and White Yam varieties which were not affected by this disease in former years showed some infection this year.

Damping-off (*Sclerotinia sp.*). Observed on the sprouts in one seedbed.

Mottle Necrosis (cause unknown). Not as severe as in 1924, but 30 per cent of the potatoes were affected in some fields.

White Rust (*Albugo ipomoeae-panduranae* [Schw.] Swing.). Prevalent wherever sweet potatoes were grown, but the cause of little damage.

Sycamore

Blight (*Gloeosporium nervisequum* [Fcl.] Sacc.). First reported on May 27 from Camden County. Much less than in 1924.

Tomato

Mosaic (cause unknown). More abundant than usual.

Wilt (*Fusarium lycopersici* Sacc.). More prevalent than usual. Losses for the state estimated at 10 per cent. The disease was most severe on the lighter soil types.

Early Blight (*Alternaria solani* [E. & M.] Jones and Grout). Less than usual, the cause of only slight losses.

Collar Rot (*Macrosporium* sp.). Reported in May and June from plant beds in Camden, Burlington, Salem and Cumberland counties. In a number of cases every plant was affected. When the diseased plants were set in the field they broke off at the lesion. Where the plants were set deep little difficulty was experienced.

Leaf Spot (*Septoria lycopersici* Speg.). Less than usual. First appeared in June on the early crop, but was checked by the hot dry weather. Again appeared late in September but was too late to result in serious losses. Estimated loss for the state, 3 per cent.

Anthracnose (*Colletotrichum phomoides* [Sacc.] Ches.). Much less than usual.

Soft Rot (*Oospora lactis parasitica* P. & P.). Very severe in sections of Burlington County following spray injury.

Leaf-Mold (*Cladosporium fulvum* Cke.). Reported from several greenhouses.

Tulip

Gray Mold (*Botrytis* sp.) One report from Cumberland County.

Turnip

Scab (*Actinomyces scabies* Thaxt.). One report from Monmouth County.

Walnut

Leaf Spot (*Marssonia juglandis* [Lib.] Sacc.). Reported from northern New Jersey.

Watermelon

Wilt (*Fusarium vasinfectum* Atk.). First reported July 29 from Burlington County. Less prevalent than usual.

Anthracnose (*Colletotrichum lagenarium* [Pass.] E. & H.). First reported August 20 from Burlington County. Severe only on late maturing crops.

Wheat

Bunt (*Tilletia laevis* K.). Very heavy infection observed in one field in Middlesex County.

Scab (*Gibberella saubinetti* [Mont.] Sacc.). Generally prevalent, but not severe.

Leaf Rust (*Puccinia triticina* Eriks.). Generally distributed, but not the cause of serious loss.

Loose Smut (*Ustilago tritici* [Pers.] Rostr.). Loss for the state estimated at 1 per cent.

Wild Lettuce

Mildew (*Sphaerotheca castagnei* Lev.). One report from Middlesex County.

Wild Lupine

Mildew (*Erysiphe communis* [Wallr.] Fr.). One report from Middlesex County.

POTATO SPRAYING IN 1925

William H. Martin and L. Graham Campbell

The spraying tests with potatoes were continued this year in central and southern New Jersey. The season was very dry and no late blight was observed. There was only a trace of early blight and this largely confined to the lower leaves of the plant. Leaf hoppers were abundant, however, and resulted in the early death of the plants in the plots sprayed with an insecticide only. This insect has become very prevalent and the losses from it the past three years have been much greater than from either early or late blight.

Spray tests were started on the J. Harry Kandle farm at Elmer in 1913, and have been continued since then, or 13 years in all. The results have led to a general adoption of spraying in Salem and Cumberland counties on the commercial crop and particularly on the late crop grown for seed. The value of spraying the latter crop has been so conclusively demonstrated that in the future potatoes will not be certified unless they have been thoroughly sprayed. In central New Jersey the adoption of spraying has by no means been so general as is the case in the southern part of the state, but each year more growers realize its value so that there is little question but that before long the spraying of the potato will be a common practice. Sufficient evidence has been accumulated to demonstrate conclusively that spraying will result in increased yields of potatoes, but it was considered advisable to continue these tests in order to have additional evidence and particularly to determine if environmental conditions influenced the results which might be expected to result from spraying.

Test on the J. Harry Kandle Farm

In this test, with the Irish Cobbler variety, a comparison was made of 5 5-50 bordeaux mixture applied at approximately 10-day intervals with a 10-10-50 mixture applied at intervals of 20 days. In both cases the bordeaux was made up with high-grade stone lime. The spray applications were made with a sprayer equipped with 3 nozzles per row which sprayed 4 rows at a time. The material was applied at a pressure of 175 pounds, and 100 gallons were applied per acre in every case but the first application, when approximately 75 gallons were used.

The first spray was applied on June 8 when the plants were about 6 inches high. At this time the plants were growing vigorously and no signs of insect or fungus injury were apparent. The remaining applications were made on June 17 and 29, and July 9 and 23. The plots receiving the 5-5-50 mixture were sprayed on the dates indicated above, or five times in all, while those receiving the 10-10-50 application were sprayed on June 8 and 29 and July 23, three applications in all.

The experimental area, which was without marked irregularities, was divided into plots each four rows wide and so arranged that a check plot alternated with two treated plots. The check plots were sprayed with arsenate of lead at the first application and the poison was likewise added to the bordeaux mixture. In the absence of the Colorado beetle no additional applications of arsenical were made. The various treated plots were replicated 5 and the check plots 6 times. Yield records were obtained on the two center rows of each plot, the area of the plots as harvested being approximately 1/40 acre. The different plots were harvested on August 12 and 13.

At various times careful observations were made on the condition of the plots in regard to general vigor and freedom from insect and fungus attack. Little difference was observed during June, but on July 9 the check plots showed considerable leaf hopper injury, while the sprayed blocks showed only a trace. On July 23 the counts were made of the number of dead leaves on every fifth plant in one row of each of the plots. In addition, a representative sample of the green leaves was collected and counts made of the number of flea beetle punctures. In collecting the leaf samples one lot was taken from the lower and another from the upper part of the plant.

The results of these observations are presented in table 1.

TABLE 1

Yield Per Acre, Number of Dead Leaves and Flea Beetle Punctures on the Various Treatments

Treatment	Yield per Acre	Dead leaves	Flee Beetle Punctures	
			Lower leaves	Upper leaves
	bu.	*per cent*		
Check	78.0	47.9	165.0	146.6
5-5-50	130.8	3.7	89.2	78.8
10-10-50	119.0	5.3	122.6	69.0

As previously indicated, most of the killing of the leaves on these plants resulted from the activities of leaf hoppers. It will be seen from the data in table 1 that the injury from this cause was greatly reduced on the sprayed plots.

Only slight differences were noted between the plots sprayed with 5-5-50 and those sprayed with 10-10-50 bordeaux mixture. It will be observed that regardless of the treatment the older leaves collected from the base of the plant showed more flea beetle punctures than the younger leaves. This is as would be expected, since the older leaves were exposed to attack for a longer period of time. In case of both the old and the younger leaves, particularly the latter, there was a considerable decrease in the number of punctures on the sprayed as compared with the unsprayed plants. On the old leaves the 5-5-50 application afforded much better protection against flea beetles than did the more concentrated spray mixture. On the younger leaves, however, the latter material gave slightly better results. This difference is probably due to the fact that the new growth was better protected in the early season by spray applications made at 10 rather than at 20-day intervals. Later in the summer when fewer new leaves were being formed the applications made at the longer intervals were sufficient to maintain a coating on the leaves.

After July 23 the check plots went down very rapidly while the plots sprayed with 10-10-50 bordeaux mixture showed but little more injury than did those sprayed with the 5-5-50 mixture.

The yields of the various plots are shown in table 1. It will be observed that the average yield of the check plots was 78 bushels as compared with 130.8 and 119.0 for those sprayed with the 5-5-50 and 10-10-50 mixtures. It is apparent that although the former material gave the greater yield increase the use of the 10-10-50 mixture gave very satisfactory results. This is especially true when it is considered that 5 applications were made of the one and only 3 of the other. There is some question, however, as to the advisability of using this material when diseases are a factor, and this would be particularly true were late blight present. Comparative tests with these two materials will be continued to determine this point. Should the use of the more concentrated material be satisfactory from the standpoint of both insect and disease control, the saving in time resulting from the fact that fewer applications would be necessary is worthy of consideration.

Test on the I. B. Van Derveer Farm

This test was conducted with the Irish Cobbler and Gold Coin varieties. A comparison was made of 5-5-50, 10-10-50 bordeaux mixture and two copper dusts, copper-lime carrying 6 per cent metallic copper and copper hydrate carrying 38 per cent metallic copper. The latter two materials were applied in such quantities as to give approximately the same amount of copper per acre as contained in the 5-5-50 bordeaux mixture. On the Irish Cobblers the 5-5-50 bordeaux and the copper dusts were applied on June 5, 15 and July 6, 16 and 27, while the 10-10-50 mixture was applied on June 5, 26 and July 16. The spray applications were made at the rate of 100 gallons per acre at a pressure of 175 pounds. The boom was adjusted to spray 4 rows at a time, with 3 nozzles per row. The dust treatments were made with a traction duster equipped with two outlet pipes to the row. All dust applications were made early in the morning when dew was still present on the plants. The plots were four rows wide and their arrangement was such that a check plot alternated with four treated plots. In the test with the Irish Cobbler variety each treatment was replicated 4 and the checks 5 times. In the test with the Gold Coin the treated plots were replicated 4 and the checks 6 times.

Test With the Irish Cobbler Variety

At the time of the first spray application, when the plants were 6-8 inches high, no diseases were observed in the field, but flea beetles were present. As the summer advanced flea-beetle injury became very prevalent and in July leaf hoppers made their appearance in large numbers. At no time during the summer, however, did diseases appear in any amount, only a trace of early blight being present and this confined to the lower leaves of the plants in the check plots. On July 20 careful observations were made to determine the number of dead leaves on the various plots as well as the flea-beetle punctures on the remaining green leaves. Most of the dead leaves were the direct result of the activities of leaf hoppers although some of the injury was undoubtedly due to tip burn. The results of these observations are presented in table 2.

TABLE 2

Yield Per Acre, Number of Dead Leaves and Flea Beetle Punctures on the Various Treatments

Treatment	Flea-Beetle punctures per leaf, average	Dead leaves	Yield per acre
		per cent	*bu.*
Check	105.6	27.3	193.9
Copper-lime dust	86.2	17.2	213.4
Copper-hydrate dust	100.8	16.0	206.4
5-5-50 Bordeaux	42.7	7.4	247.7
10-10-50 Bordeaux	75.3	11.6	235.8

It will be seen that the leaves from the check plots showed the greatest number of flea-beetle punctures per leaf, although the plots dusted with copper-hydrate showed nearly as many. The leaves from the plants dusted with copper-lime dust and from those sprayed with 10-10-50 bordeaux mixture showed a considerable decrease, but the control was not as efficient as on the plots sprayed with the 5-5-50 bordeaux mixture. On the basis of dead leaves the 5-5-50 mixture showed least, the plots sprayed with 10-10-50 were next, while there was little difference between the two dusted plots. Both were, however, slightly better than the checks. Later in the summer greater differences were apparent between the sprayed and check plots. Most of the leaves on the former were still green when the greater part of the leaves on the check plots were dead. A similar though less marked difference was observed between the plots sprayed with 10-10-50 and those sprayed with the 5-5-50 mixture, while the dusted plots were but little better than the checks.

The various plots were harvested on August 17 and the yields obtained on the two center rows of each. The average yield of the various treatments are shown in table 2. It will be seen that the plots sprayed 6 times with 5-5-50 bordeaux mixture gave highest yields, an increase of 53.8 bushels over the check plots. It is interesting to note that the plots sprayed 3 times with 10-10-50 bordeaux mixture gave an average increase of 41.9 bushels, only 11.9 bushels less than that following the use of the standard mixture. The results with the two copper dusts were not satisfactory, the average increases over the check being 20.4 and 12.5 bushels for the copper-lime and copper hydrate dusts, respectively.

The results with the copper-lime dust are in accord with those secured in previous years. It is much less efficient in the control of leaf hoppers and flea beetles than is bordeaux mixture and tests conducted in previous years show that it will not control early or late blight as efficiently as will bordeaux. The results with the 10-10-50 mixture are interesting in that they are approximately identical with those obtained at Elmer. It is true that this was an unusually dry season and consequently but little of the spray materials washed from the leaves. In a wet season the results may be different, but it is clear from the data at hand that under conditions such as were experienced this summer, this material has some promise.

Test With the Gold Coin Variety

In this test a similar comparison was made of the liquid and dust fungicides. The 5-5-50 bordeaux was applied on June 5 and 15, July 6. 16, and 27, and

August 6 and 17, making 7 applications in all. The dust treatments were made on the same dates with the exception of August 17. This last application was omitted since most of the leaves on the dusted plants were dead at this time. The 10-10-50 mixture was applied on June 5, July 6, July 27 and August 17.

The methods adopted in this test were identical with those indicated for the Irish Cobbler variety in this same field. The plots were carefully examined on August 17 and counts made of the number of dead leaves. The average of these counts together with the average yields of the various treatments are presented in table 3.

It will be observed from the table that on August 17 most of the leaves on the check plots were dead while the condition of the foliage on the dusted blocks was but little better. As in the other tests most of this injury was due to leaf-hoppers. The condition of the sprayed plots at this time was excellent, showing as they did only 5 and 7 per cent of dead leaves for the plots receiving 5-5-50 and 10-10-50 bordeaux mixture, respectively. It is apparent that up until this date the liquid sprays had afforded almost complete protection against the leaf-hopper, while the dusted plants were but poorly protected.

The yield of the various plots was obtained on September 11 and the average yield for the various treatments is presented in table 3. The yield of the plots dusted with copper hydrate was but little better than that of the checks, while the copper-lime treated plots showed a slight decrease as compared with the check plots. Here as in the tests previously discussed, the use of these two materials was of but little value in the control of leaf hoppers. An appreciable increase in yield resulted from the use of both the 5-5-50 and 10-10-50 mixtures, amounting to 77.3 and 77.8 bushels, respectively.

The results are of very great interest in that three more spray applications were made in the case of the more dilute or standard mixture. The results indicate the importance of the amount of material per acre in the control of the leaf hopper. There is little question but that the increased covering of the more concentrated material is of advantage in the control of this insect since the action of the bordeaux mixture is of a repellant rather than insecticidal nature.

TABLE 3

Yield Per Acre and Number of Dead Leaves on the Various Treatments

Treatment	Yield per Acre	Number of Dead Leaves
	bu.	*per cent*
Check	216.2	95.0
Copper hydrate dust	230.0	75.0
Copper-lime dust	212.7	80.0
5-5-50 Bordeaux	293.5	5.0
10-10-50 Bordeaux	294.0	7.0

Spraying Test With Late-Crop Cobblers on the J. H. Kandle Farm

In this test the crop was planted late in the summer and the first spray application was not made until September 8. Following this first application three others were made on the blocks sprayed with 5-5-50 bordeaux mixture and copper hydrate on September 18 and 28, and October 8, and one other, on September 28 on the blocks sprayed with 10-10-50 bordeaux mixture. As the result of the late planting the growing season was very short and this, coupled with the fact that little insect or disease injury was noted in the field, accounts for the slight yield increases resulting from spraying. In adjoining fields where the crop was planted earlier and was sprayed by the owner, the yield difference in favor of the spray applications was much more apparent. In previous years, particularly since 1919, spraying the late crop has, in almost every case, resulted in considerable yield increases. One or two exceptions to this have been noted and these occurred in cases similar to this, either when the crop was planted extremely late or when an early frost killed the vines while still growing vigorously.

The yield of the various treatments was obtained on October 29 and the average yields are presented in table 4.

The yield differences in any case are not great and consequently any conclusions drawn from the data are likely to be misleading. It is of interest to note, however, that the copper hydrate gave the highest yield. In this test this material was applied as a spray. No injury to the foliage was observed as the result of the treatment. The plots receiving two applications of 10-10-50 Bordeaux mixture slightly outyielded those sprayed four times with the 5-5-50 mixture.

Table 4

Treatment	Yield per Acre
Check	102.9
Copper Hydrate	112.0
5-5-50 Bordeaux	104.1
10-10-50 Bordeaux	110.5

Summary

Three spray tests were conducted on the commercial crop, two with the Irish Cobbler and the third with the Gold Coin variety.

In these tests leaf hopper injury was very prevalent with only a trace of early blight and no late blight.

A comparison was made of 5-5-50 bordeaux mixture applied at approximately 10-day intervals (standard treatment) with 10-10-50 applied at 20-day intervals. In the first test 5 applications of 5-5-50 gave an average increase of 52.8 bushels per acre as compared with 41 bushels for 3 applications of 10-10-50. In the second test 6 applications of the former material gave an increase of 53.8 bushels and 3 applications of the latter 41.9 bushels per acre. With the Gold Coin variety 7 applications of 5-5-50 gave an increase of 77.3 and 4 applications of 10-10-50, 77.8 bushels increase.

In tests with the Irish Cobbler and Gold Coin varieties the use of copper-hydrate or copper-lime dust failed to control leaf hoppers and gave only slight yield increases over the check plots.

In a spraying test with the late-crop variety the lateness of planting coupled with the early killing of the vines by frost resulted in a very short growing season, and was responsible for the failure of the spray treatments to show increased yields.

APPLE BLOTCH STUDIES

William H. Martin

During the past year studies were conducted to determine the time of infection of the blotch organism and in addition an effort was made to determine the most economical spray measures to adopt for the control of this disease. The results of these investigations are reported briefly here.

These tests were conducted with the Smith Cider variety in an orchard where the disease had previously been very severe. The trees were 35 years old and the grower reported that in the past he had harvested but little clean fruit. The experimental area, consisting of two rows of 19 trees each, was divided into four blocks. One tree, approximately 20 feet from the experimental block, was left unsprayed throughout the season to serve as a check.

On this tree from 20 to 40 apples were bagged each week starting May 18, ten days after petal fall, and continuing until June 30. Blotch was first observed on the fruit on June 22. At the time of harvesting the crop the bagged apples were removed and carefully examined for the presence of blotch. The results of this examination are presented in table 1.

TABLE 1

Results From Bagged Apples Harvested October 2, 1925

Date Bagged	Total Fruit	Diseased Fruit
		per cent
May 18	35	. . .
May 26	27	1.1
June 1	12	0.8
June 8	14	50.0
June 15	23	30.4
June 22	16	31.2
June 30	18	66.6

It will be observed that while the first infection was found on the apples bagged May 26, the percentage of fruit diseased was very small. The same was true for those bagged June 1, but on the following week 50 per cent of the fruit showed infection. It is apparent that, while most serious infection resulted between June 1 and 8, or at about the time of the regular 28-day spray, some infection resulted prior to this date. In former years it was believed that for best results in the control of this disease it was necessary to apply one or two accessory spray applications following the 28-day spray. While the results secured the past summer suggest that this may be of value, it is clear that infection takes place somewhat earlier than was formerly believed and consequently the applications made 17 and 28 days after petalfall are important in the control of the disease.

In tests conducted in previous years, the disease was only partially controlled following the use of concentrated lime-sulfur. In view of this fact a comparison was made this year of concentrated lime-sulfur applied in a dilution of 1-40 and 2-4-50 bordeaux mixture. The dates of the various applications are shown in table 2. On blocks 1 and 4 the regular spray schedule was followed up to and including the 28-day spray. An accessory application was then made 42 days after petalfall. On all of the blocks the last application of the regular schedule, made 10 to 11 weeks after petal-fall was omitted, due to the fact that the season was dry and consequently there was but little danger of late summer infection. On block 2, two accessory sprays were made and on block 3, two applications, made 14 and 21 days after petal-fall, substituted for the regular 17-day spray.

TABLE 2

Dates of Spray Applications

Application No.	Date	Block 1	Block 2	Block 3	Block 4
1	Mar. 27	Del. Dor.	Del. Dor.	Del. Dor.	Del. Dor.
2	April 28	Pink	Pink	Pink	Pink
3	May 7	Petal-fall	Petal-fall	Petal-fall	Petal-fall
4	May 14	7-day	7-day	7-day	7-day
5	May 21			14-day	
6	May 26	17-day	17-day		17-day
7	May 28			21-day	
8	June 4	28-day	28-day	28-day	28-day
9	June 19	42-day	42-day	42-day	42-day
10	July 3		56-day		

Applications 1 to 7 on all blocks and numbers 8 and 9 on block 4 made with lime-sulfur 1-40.

Applications 8, 9 and 10 on blocks 1, 2 and 3, made with 2-4-50 bordeaux mixture.

All sprays were applied with a spray gun at a pressure of 225 pounds. Very little burning of the leaves resulted from the use of either spray material and the amount of russeting on the fruit was so slight that no records were obtained on it when the crop was harvested and examined.

Disease counts were made on all of the fruit on three trees on blocks 1 and 3 and two trees on blocks 2 and 4. Records were obtained on both the picked and the fallen fruit. In obtaining the records the fruits were divided into two classes, salable and unsalable. The salable fruits were further sub-divided into clean and those having 1 to 5 lesions, and the unsalable into those with 5 to 10 and those with more than 10 lesions. The results of the examination are presented in table 3.

TABLE 3

Results of Spraying for the Control of Blotch

	Total Fruit	Salable Fruit				Unsalable Fruit			
		Clean fruit		1-5 Lesions		5-10 Lesions		10 Lesions	
		number	*per cent*	*number*	*per cent*	*number*	*per cent*	*number*	*per cent*
Block 1									
Pick	4523	3510	77.6	883	19.5	80	1.8	50	1.1
Drop	715	473	66.1	72	10.0	90	12.5	80	11.4
Block 2									
Pick	564	454	80.5	92	16.4	10	1.7	8	1.4
Drop	No counts made. Crop very light on all trees in block.								
Block 3									
Pick	3790	3271	86.3	459	12.1	42	1.1	18	0.5
Drop	361	286	79.3	34	9.4	14	3.8	27	7.5
Block 4									
Pick	3501	1683	48.1	1058	30.2	541	15.4	219	6.3
Drop	1293	704	54.4	166	12.8	161	12.5	262	20.3
Check									
Pick	830	96	11.5	255	30.8	257	30.9	222	26.8
Drop	962	79	8.2	36	3.7	156	16.2	691	71.9

On the check tree only 11.5 per cent of the picked fruit was clean and 57.7 per cent showed more than 5 blotch lesions. Of the drops, only 8.2 per cent were clean while 88.1 per cent showed more than 5 lesions. A considerable proportion, 49.6 per cent of the fruit on the unsprayed tree, had fallen before harvest. While part of the drop was no doubt due to the failure to control insects the indications are that it was to a considerable extent due to the presence of blotch. This is evident from the fact that only 17 per cent of the fruit had dropped on block 1, 8.6 per cent on block 3 and 29.7 per cent on block 4. In block 2, only two trees bore fruit and the yields of these two were so light that no records on dropped fruit was obtained. It is apparent, however, that a rather definite correlation exists between the amount of dropped fruit and the severity of blotch on the different blocks.

Block 4, which was sprayed with concentrated lime-sulfur throughout the season, showed an increase in clean fruit of 36.6 per cent and a decrease of 34 per cent in unsalable fruit as compared with the check tree. There was also a considerable increase in clean fruit among the drops. Much more efficient control was obtained, however, on the other three blocks which received the late summer applications of bordeaux mixture. On block 3, for example, 86.3 per cent of the fruit was clean and only 1.6 per cent showed more than 5 blotch lesions. This treatment resulted in a decrease of 56.1 per cent unsalable fruit as compared with the check and a decrease of 22.1 per cent over the blocks sprayed with concentrated lime-sulfur. It will be recalled that this block, in addition to the accessory spray of bordeaux mixture, made 42 days after petal fall, was sprayed 14 and 21 days after petal-fall, while block 1, which likewise received the extra spray application of bordeaux mixture, received only one application, made 17 days after petal-fall. On the basis of clean fruit, block 3 gave an increase of 8.7 per cent over block 1. This difference is small, however, and it is questionable if the extra amount of clean fruit would pay for the additional spray applications, especially in view of the fact that there was a difference of only 1.3 per cent in the amount of unsalable fruit. On block 3, which received an additional late summer spray, 56 days after petal-fall there was only 2.9 per cent more clean fruit than on block 1.

The results indicate that the use of concentrated lime-sulfur following the regular spray schedule will not give satisfactory control of blotch where the disease has previously been severe. Where this condition exists, the regular spray schedule, using lime-sulfur 1-40 up to and including the 17-day spray, followed by two applications of bordeaux mixture, one made 28 and the other 42 days after petal fall, will give very good control of blotch. In a dry year it is questionable if more than these two applications of bordeaux need be made. In a wet season, however, it would probably be necessary that an additional application be made approximately 10 days later.

APPLE-SCAB STUDIES

WILLIAM H. MARTIN AND E. S. CLARK

During the spring and early summer of 1925 studies were conducted at Moorestown and New Brunswick to determine the time of maturity and discharge of ascospores of the apple-scab fungus in relation to environmental conditions and development of the blossom buds. In addition, apple leaves bearing the perithecial bodies were collected from several localities at different dates to determine the condition of the spores. Leaves collected from Vineland on April 9, showed that while the asci were apparently fully developed, the ascospores had not yet formed. On April 15, however, a few mature spores were found and when these leaves were placed in moist chambers a considerable number of spores were mature the following day. Leaves were collected at Moorestown on March 13 and at frequent intervals afterward. At the time of the first examination, no asci were found, but by April 1 they had fully developed and mature spores were present on April 25. Leaves collected April 15 in Sussex County showed the asci to be forming. On April 20 they were fully developed and the ascospores were beginning to form. These were mature on April 25.

Ascospore Discharge Studies

In order to study the time of discharge of the ascospores, 10 apple leaves bearing the perithecial bodies were placed in the A. J. Roberts orchard at Moorestown and ten others at the College Farm, New Brunswick. The leaves were fastened to the ground by matches placed over the ends and these in turn held in place by means of wires buried in the ground. On the matches on each leaf a glass slide was placed. This slide was covered with a thin film of mineral oil so that when the ascospores were discharged they were caught and held in the film of oil. The slides were removed each morning, usually before eight o'clock, and replaced with fresh ones. The exposed slides were then examined for the presence of the ascospores.

The results of the studies conducted at Moorestown are summarized in figure 1. The slides were set up in this orchard on April 4, but no spore discharge was recorded until April 25-26. It will be observed from the chart that while there was some rainfall on April 15, 17 and 19, no spores were discharged, due to the fact that they were not yet mature. The discharge of ascospores occurred over a period of 48 days, the last discharge being recorded on June 11-12. While it is possible that there may have been still other spore discharges after this date, it is questionable, since none accompanied the rain on June 15.

It will be noted from the figure that in almost every case the spores were discharged on days when there was rainfall or on the day following a rain. Only one exception to this is noted, on June 6-7, when a light discharge of ascospores was recorded.

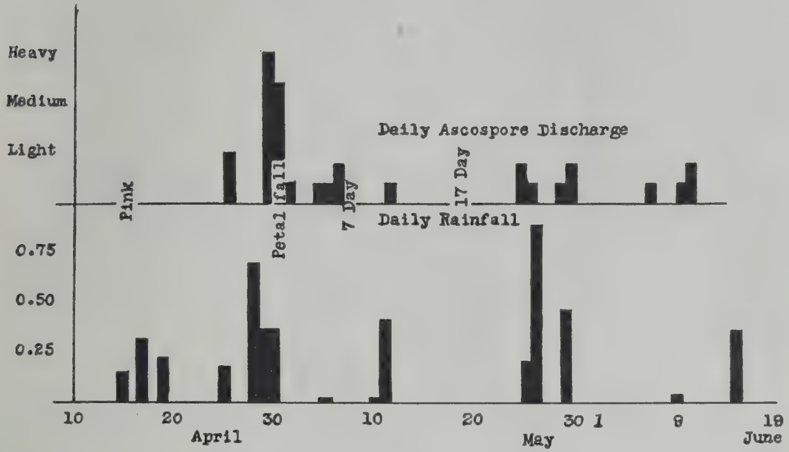


FIG. 1. RECORD OF ASCOSPORE DISCHARGE OF THE APPLE SCAB FUNGUS IN RELATION TO RAINFALL—A. J. ROBERTS ORCHARD, MOORESTOWN, 1925

During the period of observation there were 15 days on which spores were discharged. It should be noted, however, that the period of heaviest discharge occurred between April 25 and May 10. In this orchard the pink spray application was made on April 16 and the petal-fall and 7-day application on May 1 and 8, respectively. It is obvious, from a consideration of these data, that while the pink application was important in the control of scab the delayed dormant or even the pre-pink would have been of but little value.

Results at the College Farm

In the studies conducted at the College Farm the first discharge of ascospores occurred April 28 and the last on June 19, a total discharge period of 52 days. No spores were discharged after June 19 despite the fact that there was considerable wet weather following that date, over an inch of rain falling on June 30.

In this test there were 18 discharge periods in all, and as in the orchard at Moorestown, they occurred for the most part either during or following a rain. The heaviest discharge period occurred between April 27 and May 11, spores being caught on 9 days during this time. It will be noted from figure 2 that this period fell between the pink and 7-day applications, indicating that an application made before the pink would have but little value in the control of scab.

These results were obtained in central and south central Jersey, but there is reason to believe that the same situation does not exist in north Jersey. As previously indicated, the leaves collected at Glenwood, Sussex County, showed mature ascospores on April 25. In this orchard the delayed-dormant spray was applied on April 16 and the pink spray not until April 29. It is obvious from this that had no spray application been made previous to the pink, difficulty might have been experienced in the control of scab.

The results of this season's study of the development of the ascospores are of interest, indicating as they do a considerable variation in time of development of the ascospores in northern and southern Jersey in relation to the development of the fruit buds. They suggest that while an application made before the regular pink is probably of little value in central and southern Jersey, in the northern part of the state a pre-pink or delayed-dormant application may be important for the control of scab.

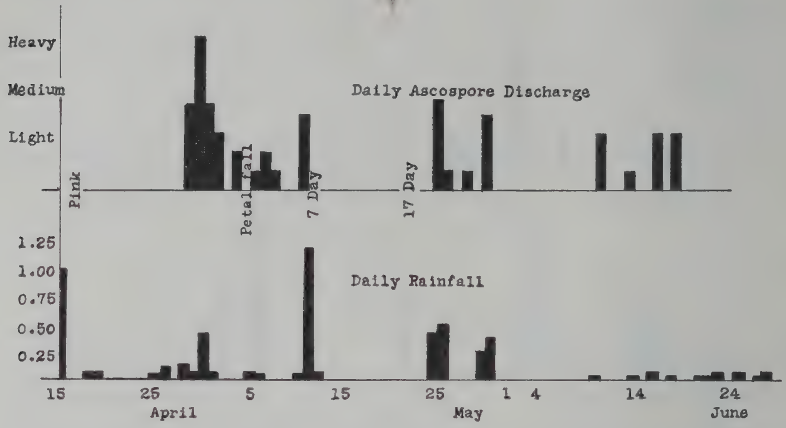


Fig. 2. Record of Ascospore Discharge of the Apple Scab Fungus in Relation to Rainfall—College Farm, New Brunswick, 1925

PEA ROOT-ROT STUDIES

C. M. Haenseler

Studies on the root-rots of the garden pea were continued along much the same lines as in previous years. The major studies this year were centered on the root-rot caused by *Aphanomyces euteiches* Drechs. and the present report will be limited to the work on this organism.

Soil Temperature and Infection

The root-rot caused by *Aphanomyces euteiches* is rarely found in New Jersey before the middle of May, and in abnormally cool springs such as that of 1926 it appears much later. On early plantings in cool springs, infection sometimes takes place so late that even on heavily infected soils the yields are not appreciably reduced by the disease, while later plantings on the same soil may be completely destroyed. It is evident from such field data that soil temperature is an important factor in determining the time of appearance of the root rot but little is known as to the exact soil temperatures necessary for infection. Studies have been started to determine this point and a summary of the first year's records will be given here. Maximum and minimum soil temperatures were taken daily in a naturally infected soil and records taken on the date of first appearance of root-rot. An attempt was then made to find some correlation between either the maxima or minima or the mean soil temperature and the time of infection. The first above ground symptoms of the disease were noted on June 11. Since it requires about 7 to 10 days after infection for the disease to become visible above ground, infection must have taken place about June 1. The maximum and the mean daily temperatures fluctuated so irregularly during the period of the test, April 25 to June 18, that no correlation could be seen between these temperatures and infection. The minimum soil temperatures, however, were much more regular, increasing rather gradually from 3.75° C. on April 27 up to 18.75 at the end of the test period.

It is significant that up to May 27 there were only four days when the minimum reached 14° or higher and these days were well scattered, May 14, 19, 21 and 24, and had periods of low minima between. Beginning May 27, however, there was an 8-day period during which the minimum did not drop below 14° C. On May 27, 28, 29, 30, 31 and June 1, 2 and 3 the minimum readings were 14, 14, 15, 14, 15, 15.25, 15.25, and 14.50, respectively. It was during this period that infection took place. It would seem from this that a minimum daily temperature of at least 14° C. lasting over a period of several days is necessary for infection.

Resistance of Aphanomyces Euteiches to Drying

In New Jersey the principal areas infected with the root-rot organism are of light sandy loam, which is very subject to blowing in wind storms. It would be quite possible for the soil particles carried in such wind storms to carry the root-rot organism for long distances, provided the accompanying desiccation would not prove fatal to the fungus. In order to test the resistance of *Aphanomyces euteiches* to drying, soil from a naturally infected field was placed in thin layers in a greenhouse and exposed to the direct rays of the sun. After drying for various intervals from 3 days up to 6 weeks, samples of this air-dry soil were placed in pots and planted with Alaska peas. Infection took place regardless of the time of desiccation, showing conclusively that the oogonia of *Aphanomyces euteiches* may retain their viability after remaining in a dry soil exposed to the sun for at least six weeks. It is quite possible, therefore, that the root-rot organism might be transported from place to place and possibly for long distances by wind-blown soil particles without being destroyed by the drying. Any other agency which might transfer soil particles from an infected field could also carry the root-rot disease.

Hosts of the Pea Root-Rot Organism

Information has also been obtained which throws further light on the probable means whereby the root-rot organism exists in the soil for a period of years between pea crops. It is well known that the fungus which causes root-rot overwinters in the oospore stage, thus carrying the organisms over from one year to the next, but little is known at present as to how the root-rot fungus persists for a long period of years between successive crops of peas. Severe infection of root-rot sometimes occurs in fields where peas have not been grown for ten or more years, thus indicating that the organism must either be able to live saprophytically in the soil or else have hosts other than the pea. In 1925 it was shown for the first time that certain plants besides the pea are susceptible to the root-rot fungus and might act as hosts to tide the organism over from year to year. Inoculation experiments conducted this year have added a few other species to the list of hosts. Up to the present time the plants which have been successfully infected with pure culture inoculation of *Aphanomyces euteiches* are as follows: Garden pea, Canada field pea, sweet pea, hairy vetch, cowpea and sweet clover. Mature oogonia of the fungus were developed in each of these host plants, though no above-ground effects from the infection could be noted in the case of the cowpea and sweet clover. In the sweet clover only a single diseased root was found which contained mature oogonia of the root-rot organism but this is sufficient to show that under favorable conditions the organism might multiply on this host.

Furthermore, a great abundance of oogonia containing normal mature oospores have developed in parts of various plants placed in water and inoculated with a suspension of zoospores of *Aphanomyces euteiches.* A large variety of plants were thus tested and 14 days after inoculation an examination showed an abundance of normal oogonia in root tips and rootlets of crimson clover, roots of navy bean, roots, petioles and leaf blades of red kidney bean, petioles of spinach, and leaf sheath of timothy. It is evident from these tests that the root-rot fungus has a number of hosts in addition to the pea in which it may develop an abundance of oospores to prolong its existence in the soil.

It also seems highly probable that the organism may develop as a saprophyte in the dead parts of a number of plants.

Effect of Root-Rot on Transpiration

Two attempts were made to determine the effect of root-rot on transpiration of the pea. In both cases glazed earthenware pots equipped with glass tubes leading from the surface to an inverted flower pot in the center, were planted with Alaska peas and the surface sealed with a paraffin-vaseline mixture when the plants were about 3 inches high. After sealing, a zoospore suspension was introduced about each plant in certain pots and other pots were left uninoculated. Daily transpiration records were obtained from the time of inoculation up to maturity of the plants. In the first experiment, run at soil moisture contents of 20 and 80 per cent saturation, no infection was obtained in either series. The test was repeated with one moisture content (60 per cent saturation) and only 17.5 per cent of the inoculated plants became diseased. One pot not sealed with paraffin, but otherwise handled in the same way, gave 100 per cent infected plants. Either the lack of aeration or the paraffin mixture seemed to prevent satisfactory infection and disease development in these sealed pot experiments.

The average height and dry weight of vines were the same for the 40 inoculated and 31 uninoculated plants, 56.4 cm., and 0.32 gm. The number of peas and pods and the dry weights of these were slightly greater for the inoculated lot. In transpiration the inoculated lot was higher at the beginning and remained so up to the sixth week when it dropped below the check lot. The transpiration by weeks for the inoculated lot was 4.64, 7.24, 5.83, 6.33, 3.17 per cent greater than the check lot for the first, second, third, fourth and fifth weeks, respectively. The sixth week the transpiration was 3.73 per cent less on the inoculated than on the check. This drop in transpiration on the inoculated plants during the fifth and sixth weeks was the result of the premature dying which accompanied the disease. The injurious effects came too late in this experiment, however, to affect the yield greatly. This has generally been the case with root-rot tests conducted in the greenhouse. Even when 100 per cent of the inoculated plants become diseased there is seldom a decrease of more than 5 to 20 per cent in size and yield as compared with check plants.

Longevity of Zoospores in the Soil

It had previously been found that the zoospores of *Aphanomyces euteiches* remained active in water for a period of 5 or 6 days and that they were capable of infecting the pea as long as they were in an active state. During the past year a similar test was made with zoospores in the soil. Non-infected soil was placed into 26 1-gallon glazed earthenware pots. On each of the following dates two pots were planted with Alaska peas: January 7, 11, 15, 17, 19, 20, 21, 22, 23, 25, 27, 31 and February 4. On January 21 the entire series was inoculated with a suspension of zoospores of *Aphanomyces*. It will be seen that the inoculation in the various lots was made 14, 10, 6, 4, 2 and 1 days after planting, at the time of planting and 1, 2, 4, 6, 10 and 14 days before planting. Observations were taken at frequent intervals and final data were obtained on March 19, eight weeks after inoculation.

First above-ground signs of infection were observed on February 2, twelve days after inoculation, on plants inoculated 10 and 6 days after planting. The number of plants finally becoming infected in the various lots is shown in table 1.

It will be noted from the table that a high percentage of infection occurred on all plants which were inoculated at or after the time of planting. In the pots inoculated at different intervals before planting, the infection is somewhat irregular, but it is significant that 73.3 per cent infection occurred in pots planted 4 days before seeding while no infection was obtained in pots planted 6, 10, and 14 days after the addition of zoospores. This would seem to indicate that zoospores have a maximum existence of possibly less than 6 days in the soil, or approximately the same as the period of viability in water suspension.

TABLE 1

Longevity of Zoospores of Aphanomyces euteiches in Soil

Lot No.	Inoculated days after or before planting	Number of plants	Infected	
			Number	per cent
1	14 after	16	14	87.5
2	10 after	16	16	100.0
3	6 after	15	15	100.0
4	4 after	16	16	100.0
5	2 after	13	13	100.0
6	1 after	13	13	100.0
7	at planting	13	4	30.7
8	1 before	15	12	80.0
9	2 before	15	0	0
10	4 before	15	11	73.3
11	6 before	13	0	0
12	10 before	12	0	0
13	14 before	13	0	0

Effect of Lime and Sulfur on Root-Rot Infection

In an earlier field experiment the application of lime and sulfur to a naturally infected soil failed to show any influence on root-rot development from either treatment. A series of laboratory tests on the effect of various toxic materials on the zoospores of *Aphanomyces euteiches* showed that 1 part of calcium hydrate in 50,000 parts of water stopped the activity of zoospores in 2 to 4 minutes. This stimulated additional tests on the effect of lime and sulfur on infection.

In one experiment 14 1-gallon glazed earthenware pots filled with non-infected soil were treated with various amounts of hydrated lime and sulfur, immediately before planting to Alaska peas. After germination the pots were thinned to 8 plants per pot and on February 10, when the plants were 25 cm. high, were inoculated with a zoospore suspension of *Aphanomyces euteiches.*

The soil treatment, the pH reading of the soil extract, taken at the time of inoculation, the percentage of infection, the average height of plants, and the total dry weight of crop from the various lots, are given in table 2. The percentage of plants infected was reduced by the 4,000 pounds of hydrated lime and by all the sulfur treatments, but this reduction in infection did not result in an increased growth in these lots. The optimum pH for infection seems to be so near the optimum for pea growth that changing the soil reaction sufficient to inhibit infection injured the peas as much as or more than did the disease itself.

It is evident that hydrated lime added to the soil did not inhibit the zoospores as did the calcium hydrate in the laboratory tests. A repetition of the laboratory tests showed that the injurious effect of the calcium hydrate rapidly decreased with time. After standing a few hours, a 1 to 50,000 mixture had practically lost its toxicity, due doubtless to the action of CO_2 of the air on the hydrate. The possibility still remained that lime added to the soil might inhibit infection for a period of several days. To test this possibility, a second pot experiment consisting of 10 pots was conducted as follows: two pots were treated with 2,000 pounds and 2 with 1,000 pounds of hydrated lime per acre 10 days before inoculation. Two other lots were given the same lime treatments as the above, but only 2 days before inoculation. Two check pots were left unlimed. All 16 plants in each of the 10 pots became infected regardless of the amount of lime applied or the time of application. The only noticeable effect was a 12 per cent decrease in dry weight in the pots receiving 2,000 pounds of lime 10 days before inoculation. A maximum of 2 per cent difference in dry weight was shown by the other pots.

TABLE 2

Effect of Lime and Sulfur on Pea Root Rot

Lot	Treatment pounds per acre		pH	Number of Plants	Infection	Total dry weight aboveground portion	Average height of plants
	Lime	Sulfur					
					per cent	*gm.*	*gm.*
1	4000	..	7.4	16	43.75	8.295	54.3
2	2000	..	6.8	16	100.00	8.975	61.2
3	1000	..	6.6	16	100.00	9.910	59.6
4	..	..	5.5	16	100.00	8.980	61.1
5	..	300	4.6	16	0	9.260	56.4
6	..	600	4.2	16	0	8.660	61.0
7	..	1200	4.0	16	0	7.100	55.0

A sulfur and lime test was also conducted in 2 by 2-foot soil boxes filled with naturally infected soil. Here again applications of 1,000 pounds of hydrated lime per acre showed no effect on root-rot infection. In boxes receiving 300 pounds of sulfur there was a reduction in the number of infected plants, but the growth of the plants was decreased by the treatment.

Likewise in a pot experiment with a naturally infected soil the application of 200, 400 and 800 pounds of sulfur per acre prevented infection completely, but here again growth was appreciably reduced in those series where sufficient sulfur was added to prevent infection. One hundred pounds of sulfur per acre failed to prevent infection in this experiment.

It seems evident from these tests that there is little hope of reducing losses from root-rot by adjusting the soil reaction with lime or sulfur. Liming favors the growth of the peas but also encourages the disease. Sulfur, on the other hand, may reduce or prevent the disease but the quantity of sulfur necessary to prevent infection seems to injure the crop as much as or more than the disease itself.

There seems to be a narrow range in soil reaction which partially inhibits the root-rot organism and yet does not seriously injure the peas but further study is necessary to determine the exact limits of this range, and to determine whether it may be of value in working out practicable control measures.

Possible Control Measures

Since no direct means of controlling root-rot are as yet known the grower must look to partially resistant varieties and proper cultural practice to reduce the losses from this disease. In 1926, as in former years, the World's Record and Sutton's Ideal held up better on infected soil than the other standard varieties used in this state. As a result of the good showing made by the World's Record this variety is rapidly becoming very popular in the root-rot sections. In 1925 and 1926, however, this variety suffered severely from mosaic and it seems probable that, if mosaic continues to increase in severity, root-rot may become of secondary importance in the future. In those cases where comparisons were possible between the Sutton's Ideal and World's Record the former proved to be equally resistant to root-rot and less subject to mosaic.

The use of partially resistant varieties is not a solution of the root-rot question, however. On infected soils which are poor in fertility and improperly cultivated these varieties, especially if planted late, may make a complete crop failure. The best means of reducing losses from root-rot are early planting and maintaining a high state of cultivation and fertility. As we have already seen, the root-rot organism requires a high soil temperature for infection to take place. In early plantings the vines are so far developed before infection that a high yield is often obtained in spite of the disease. This is especially true in seasons like 1926, when the cold soil prevented infection until late in the season, when early plantings were almost mature. High fertility also greatly reduces the dangers of loss. It has previously been noted that on certain farms where both manures and fertilizers are freely used on the soil, excellent pea crops are obtained on fields where 100 per cent of the plants are infected. On poor fields, on the other hand, it is not uncommon for root-rot to cause a complete crop failure. The high fertility does not control the disease on the roots but the injurious effects of the root-rot to the above-ground parts is greatly reduced where the soil is properly fed.

Summary

In 1926 infection of peas by *Aphanomyces euteiches* did not take place in naturally infected soil until there was a period of several days duration with a minimum soil temperature of 14° C. or over.

The following plants have been infected with pure cultures of *Aphanomyces euteiches:* garden pea, Canada field pea, sweet pea, hairy vetch, cowpea and sweet clover. Oögonia have also developed in abscised parts of crimson clover, navy bean, kidney bean, spinach and timothy, which were placed in a zoospore suspension of *Aphanomyces euteiches.*

Drying a naturally infected soil in thin layers exposed to the direct rays of the sun under greenhouse conditions for a period of 6 weeks failed to destroy the root-rot organism.

Infection with *Aphanomyces euteiches* does not appreciably reduce the rate of transpiration of the diseased plant until several weeks after infection.

Zoospores of *Aphanomyces euteiches* may remain viable in soil for at least 4 days but not for a much longer period.

Large amounts of hydrated lime (4,000 pounds per acre) seems to reduce the percentage of infection, but smaller amounts (2,000 or less) had no inhibiting effect.

Acidifying the soil with large amounts of sulfur will prevent infection, but the quantity of sulfur necessary to control the disease is injurious to the pea.

FURTHER STUDIES ON ARSENICAL INJURY OF THE PEACH

C. M. HAENSELER

During the past four years a series of tests have been conducted to determine the cause of a serious leaf and twig injury which has been prevalent in New Jersey peach orchards sprayed with various mixtures. The results obtained up to 1925 have been published elsewhere (1) and will not be discussed in this report. It should be stated, however, that the results of these earlier studies in every case pointed directly to the arsenical in the spray mixture as being the toxic agent and to the atmospheric conditions as being an important factor in determining the amount of injury produced. Tests similar to those of 1922 to 1924 were repeated again in 1925, with a few minor changes and additions.

The 1925 tests included a study of (a) the effect of sulfur, lime and arsenate of lead used alone and in various combinations and proportions, (b) the effect of the time of application on the amount of spray injury produced and (c) the correlation between premature defoliation and nodal cankering. The test orchard was divided into 25 blocks of three trees each with seven trees left unsprayed to serve as checks. Blocks 1 to 15 received hydrated lime, sulfur and arsenate of lead used alone and in various combinations and proportions. Calcium caseinate at the rate of ½ pound per 50 gallons of spray was added in each case. Blocks 16 to 18 were sprayed with self-boiled lime-sulfur containing a uniform amount of sulfur but with various amounts of stone lime and arsenate of lead. Blocks 19 to 24 received dry-mix, containing 8 pounds of sulfur, 4 pounds of hydrated lime, ½ pound of calcium caseinate and 2½ pounds of arsenate of lead per 50 gallons, and were sprayed at different times and at different frequencies. Block 25 was given the same spray as blocks 19 to 24, and was used for studies on the correlation between defoliation and nodal cankering.

The various spray mixtures were made up immediately before each application and were applied with a 5-gallon Vermorel knapsack sprayer, using as much pressure as was obtainable with this type of equipment. A shield screen was used to prevent the blowing of the spray to adjacent blocks, and each tree was sprayed until it dripped freely.

Observations were taken at short intervals throughout the spring and summer, and final data were taken on August 4. The first indication of spray injury was observed on June 8, seven days after the second spray application, when a slight leaf burning was noted on blocks 6, 10, 11, 12 and 14. No further development took place until about June 26, nine days after the third application, when cankering became apparent at the oldest nodes of the new growth. After

TABLE 1

Relative Amount of Leaf and Twig Injury to Peach From Various Spray Formulas and From the Different Applications

Plot No.	Type of Spray	MATERIALS IN 50 GALLONS			Spray applications*	Leaves injured	Number of ring cankers on 100 twigs	Number of nodal cankers on 100 twigs	Number of nodes slightly injured on 100 twigs	Total number of lesions on 100 twigs	Injury to 1-year-old wood, relative
		Sulfur	Lime	Arsenate of Lead							
		lbs	*lbs.*	*lbs.*		%					
1	Dry-Mix	8	0	0	1, 2, 3	0	0	0	0	0	0
2	Dry-Mix	0	4	0	1, 2, 3	0	0	0	0	0	0
3	Dry-Mix	0	0	1½	1, 2, 3	35	60	148	47	255	35
4	Dry-Mix	8	4	0	1, 2, 3	0	0	0	0	0	0
5	Dry-Mix	8	0	1½	1, 2, 3	43	56	109	37	202	30
6	Dry-Mix	0	4	1½	1, 2, 3	30	57	154	48	259	20
7	Dry-Mix	8	2	1	1, 2, 3	16	48	53	15	116	20
8	Dry-Mix	8	4	1	1, 2, 3	19	39	66	22	127	20
9	Dry-Mix	8	4	1½	1, 2, 3	19	64	97	12	173	25
10	Dry-Mix	8	4	2	1, 2, 3	22	75	258	63	396	45
11	Dry-Mix	8	4	2½	1, 2, 3	53	77	238	63	378	50
12	Dry-Mix	8	2	1½	1, 2, 3	23	82	196	70	348	50
13	Dry-Mix	8	6	1½	1, 2, 3	29	67	249	52	368	45
14	Dry-Mix	4	4	1½	1, 2, 3	30	77	164	30	271	50
15	Dry-Mix	10	4	1½	1, 2, 3	17	59	132	44	235	40
16	S.B.L.S.	8	8	1½	1, 2, 3	11	11	28	5	44	5
17	S.B.L.S.	8	4	1½	1, 2, 3	19	32	62	50	144	10
18	S.B.L.S.	8	4	2½	1, 2, 3	49	68	99	47	214	10
19	Dry-Mix	8	4	2½	1st only	7	24	7	1	31	0
20	Dry-Mix	8	4	2½	2d only	32	40	68	15	123	50
21	Dry-Mix	8	4	2½	3d only	56	39	88	17	144	40
22	Dry-Mix	8	4	2½	1st & 2d	34	55	118	14	187	40
23	Dry-Mix	8	4	2½	1st & 3d	71	68	91	15	174	50
24	Dry-Mix	8	4	2½	2d & 3d	73	64	186	31	281	50
11	Dry-Mix	8	4	2½	1st, 2d & 3d	53	77	238	63	378	50

*The first, second and third applications were made on May 18, June 1 and June 17, respectively.

this date, injury developed steadily through the remainder of June and most of July. On August 4, when the injury had apparently reached its maximum, counts were made on two representative trees in each block to determine the following:

(1) The percentage of leaves defoliated.
(2) The percentage of leaves spray injured but not defoliated.
(3) Number of girdling cankers at the base of new growth of 50 twigs.
(4) Number of nodal cankers on 50 twigs.
(5) Number of slightly injured nodes on 50 twigs.
(6) Relative amount of cankering and gumming on 1-year-old wood.

All the data are based on actual counts except that on wood injury. In the latter case the trees were carefully examined and each block given a score between 0 and 5, the score 5 representing blocks on which the 1-year-old wood on every twig showed some injury and where gumming cankers were very conspicuous.

The data obtained from these counts and the spray treatment which each block received are given in table 1. The relative amount of injury caused by the various modifications of Dry-Mix is also expressed in graphic form in figure 1, where the applications are arranged in the order of the total twig lesions produced.

EFFECTS OF ARSENATE OF LEAD

It will be noted that on blocks 1, 2 and 4 (table 1 and figure 1) where the spray contained no arsenate of lead, there was no injury of any kind. Where the lead arsenate content of the mixtures was 1, 1½, 2 and 2½ pounds per 50 gallons, respectively, the amount of injury increased directly as the arsenical increased. Although nodal injury was slightly greater on block 10 where 2 pounds of arsenate was used than on block 12 which received 2½ pounds of arsenate, the latter caused the greater total injury. This close correlation between arsenate of lead content of the mixtures and injury is more clearly brought out when we compare those mixtures in which the only variable is lead arsenate. There are two groups in which such a comparison can be made. The composition of these mixtures and the amount of injury produced by each are presented in table 2 and figure 2. The increase in injury from each increase in arsenate can be seen at a glance.

TABLE 2

Influence of Lead Arsenate Content of Spray on Spray Injury to Peach

Plot No.	Materials in 50 gallons of spray mixture	Total number of buds injured on 100 twigs	Leaf injury	Wood injury, relative
			per cent	
4	8-4-0*	0	0	0
8	8-4-1	127	19	20
9	8-4-1½	173	19	25
10	8-4-2	396	22	45
11	8-4-2½	378	53	50
7	8-2-1	116	16	20
9	8-2-1½	348	23	50

*Eight pounds sulfur, 4 pounds lime, 0 pounds arsenate of lead.

On the blocks sprayed with self-boiled lime-sulfur there is also an appreciable increase in leaf and twig injury as the arsenate of lead is increased from 1½ to 2½ pounds per 50 gallons (block 17, 18, table 1).

The amount of injury produced by the self-boiled sprays is much less, however, than that caused by Dry-Mix formulas with the same arsenate content.

Effect of Lime and Sulfur on Arsenical Injury to Leaves

In our tests of previous years it was found that arsenical injury is generally reduced as the lime content of a lime-sulfur-lead spray mixture is increased. Occasionally, however, for reasons which are not yet understood, this relationship does not seem to hold. In certain cases the addition of lime has even caused an apparent increase in injury. The 1925 tests show a tendency toward a decrease in leaf injury as the lime is increased, though there are several exceptions. On blocks 5, 12, 9 and 13, where 8 pounds of sulfur and 1½ pounds of lead arsenate were used with 0, 2, 4 and 6 pounds of lime, the leaf injury was 43, 23, 19 and 29 per cent, respectively. On blocks 7 and 8 where 8 pounds of sulfur and 1 pound of lead arsenate were used with 2 and 4 pounds of lime, there was little difference in the amount of leaf injury. In the self-boiled lime-sulfur (blocks 16, 17), increasing the lime from 4 to 8 pounds per 50 gallons reduced the leaf injury from 19 to 11 per cent. The most striking effects are seen where lime is omitted from the mixture. It will be noted, for example, that of the eight spray mixtures containing 1½ pounds of arsenate of lead per 50 gallons, there are two which caused especially severe leaf injury (fig. 1). Neither of these contained lime. In these cases it seems that the absence of lime caused the arsenical to become more injurious.

Increasing the amount of sulfur in the mixture also decreased the amount of leaf injury in most cases. On blocks 6, 14, 9 and 15, where 4 pounds of lime and 1½ pounds of arsenate of lead were used with 0, 4, 8 and 10 pounds of sulfur, the leaf injury was 30, 30, 19 and 17 per cent, respectively. Farley (2) has also found that increasing the sulfur content of Dry-Mix uniformly decreases the danger from leaf injury.

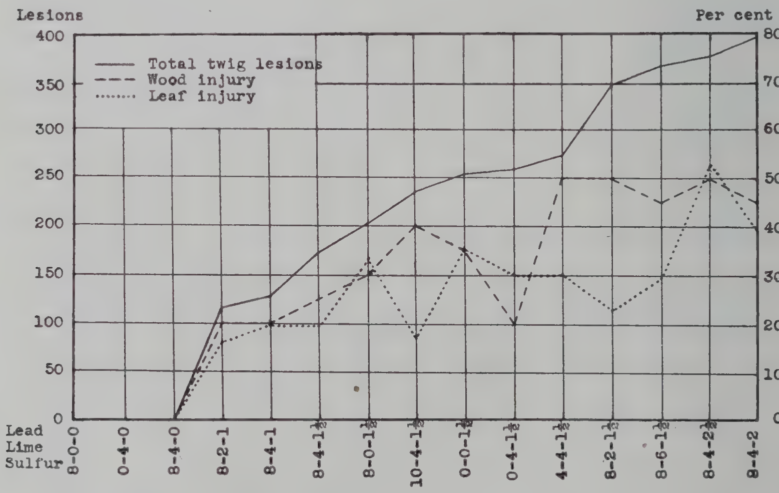


Fig. 1. Relative Amount of Injury to Peach from Dry Mix Sulfur-Lime Containing Various Amounts of Sulfur, Lime and Arsenate of Lead to Each 50 Gallons of Spray
All the Mixtures Contain ½-Pound Calcium Arsenate to Each 50 Gallons

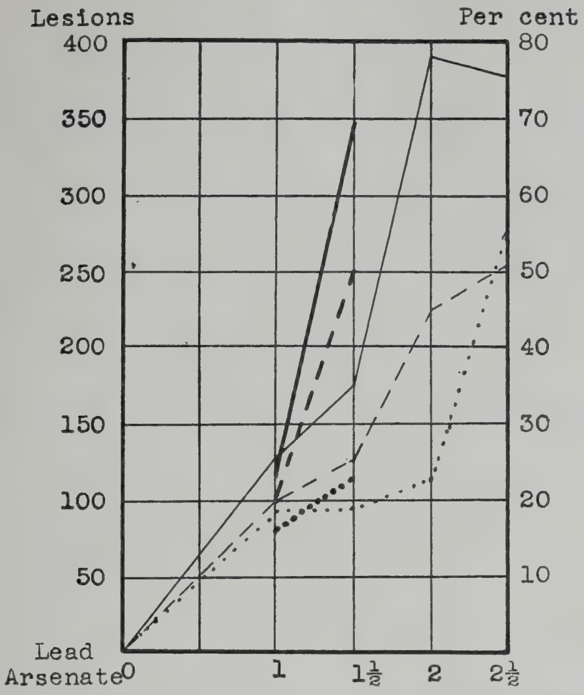


Fig. 2. Relationship Between Lead Arsenate Content of Spray Mixture and Spray Injury

Solid lines = Nodal injury.
Dash lines = Wood injury.
Dotted lines = Leaf injury.
Light lines = Spray mixture containing 8 pounds sulfur and 4 pounds lime.
Heavy lines = Spray mixture containing 8 pounds sulfur and 2 pounds lime.

Leaf Injury vs. Twig Injury

The amount of lime or sulfur in the spray mixture does not seem to affect the twig and wood injury to the same extent as it does the leaf injury. This lack of correlation between leaf and twig injury is clearly seen from the curves in figure 1. It will be noted that generally the leaf injury is very high where either lime or sulfur is omitted and lower when both lime and sulfur are present. The twig injury, on the other hand, fails to show such a relationship.

Since the beginning of our studies on arsenical injury we have observed, both in the field and on experimental blocks, that leaf injury and twig injury are not necessarily correlated. Cases have been noted where sprays containing arsenate of lead have caused severe twig cankering and abundant gummosis without causing any perceptible injury to the leaves. In other orchards the leaves were badly burned and defoliated, while the twigs showed only traces of cankering. The tests this year do not show such an extreme case, though they do show the lack of direct correlation between the two types of injury. It is evident that the factors which determine leaf injury are not identical with those that determine twig and wood injury.

TABLE 3

Relationship Between Defoliation and Nodal Cankering

Lot No.	Spray applications	Number of twigs	Artificially defoliated nodes			Nodes defoliated by spray, etc.			Non-defoliated nodes		
			Number	Cankered	Slightly injured	Number	Cankered	Slightly injured	Number	Cankered	Slightly injured
				per cent	*per cent*		*per cent*	*per cent*		*per cent*	*per cent*
1	2 after defoliation	100	250	84	7	48	67	4	1142	0	0
2	1 before 2 after defoliation	100	250	91	8	132	74	14	1352	0.07	0.44
3	None	50	200	0	1.5	13	0	0	808	0	0

Effect of Time of Application and Weather Conditions on Amount of Injury

In the 1924 tests it was found that the earliest spray application (June 7) was the one responsible for the greater part of the injury, applications made June 23 and July 11 causing only traces of burning. It seemed from these results that the maturity of the twigs might be an important factor in determining the amount of injury, the greater injury apparently occurring early in the season when the growth is soft. The results of the 1925 tests, however, indicate that this is not the case. In 1925, the earliest spray, May 18 (shuck-fall) caused only a trace of injury, while the second application, June 1, burned appreciably and the third, June 17, proved to be the most injurious (plots 19, 20, 21, table 1).

It is of interest to note in this connection that the weather conditions during the spraying seasons of 1924 and 1925 were practically reversed. In 1924 the first part of the test period was rather wet and the latter part extremely dry, while in 1925 the first part of the test period was much drier than the latter part. Spray injury in both these seasons was rather closely associated with moist weather conditions, an association which has been previously noted by the writer (1) and others (3).

From a general averaging of the data it will be seen that where two or three applications were made on a given block (blocks 11, 22, 23, 24) the injury is about equal to or slightly greater than the sum of the injuries caused by the various single applications (blocks 19, 20, 21). In case of the nodal cankers, particularly, the injury from two or three applications seems to be considerably greater than the sum of the injuries of the separate applications. This, however, is to be expected. As will be shown later, nodal cankering follows defoliation. If an earlier spray has caused defoliation the succeeding applications may be expected to cause more nodal cankering than similar applications made on trees not defoliated by an earlier spray. It would also appear from a comparison between the nodal injuries in blocks 22 and 23 that the combined effect of two successive applications becomes less as the time between the applications is increased.

Effect of Defoliation on Nodal Cankering

Where nodal cankers occur in large numbers on young twigs following the use of toxic spray mixtures, it is not always easy to determine the exact relationship between these cankers and the accompanying defoliation. Earlier observations have shown that such cankers are almost invariably found at defoliated nodes, but it was not clear whether the cankers caused defoliation or whether defoliation occurred first and the cankers resulted from the absorption of toxic materials through the open leaf traces. Adams (4) has concluded from observations in Delaware that the latter is the case, and our own studies involving close observation of 700 artificially defoliated nodes on sprayed and unsprayed trees, would point to the same conclusion.

In these defoliation tests some of the leaves were removed with a razor and others carefully pulled off. On half of the test twigs only one leaf per twig was removed, while 4 leaves were taken from the remainder. The defoliations were made on May 29 and each twig tagged and numbered. One group of 100 twigs (lot 1), with a total of 250 defoliated nodes, was on a tree which was sprayed on June 1 and 17 with standard Dry-Mix containing 2½ pounds of arsenate of lead to 50 gallons. Another group of 100 twigs (lot 2) with 250 defoliated nodes received an application on May 18, eleven days before the defoliation, in addition to the June 1 and 17 applications. A third group of 50 twigs (lot 3) with 200 defoliated nodes was on an unsprayed tree and served as a check.

On June 26, twenty-eight days after defoliation, no trace of injury was noticed. On July 13 a few nodes had become cankered and many others showed a reddening of the bark just below the bud, a symptom which has been recognized as the first stages of cankering. After that date the cankering developed rapidly so that by July 28, 55 per cent of the artificially defoliated nodes had well developed cankers immediately below the leaf trace. During the first week of September final records were taken on the number of cankered and the number of slightly injured nodes resulting from the artificial defoliation. The amount of defoliation which occurred subsequent to the beginning of the test and the number of cankered and slightly injured nodes developing on these latter were also recorded. The difference in the behavior of the razor-defoliated nodes and those defoliated by pulling was so slight that they are not treated separately. The data are presented in table 3.

It will be seen from the table that in lot 2, which received one spray before and two after artificial defoliation, 91 percent of the defoliated nodes became cankered, as compared with 84 per cent in lot 1 where the first spray was omitted. The application which was applied 11 days prior to the defoliation thus seemed to increase the nodal cankering by 7 per cent. Both of these lots show that a very high percentage of nodes defoliated before spraying may become severely cankered by subsequent sprays.

Defoliation prior to spraying is not necessary, however, for nodal cankering to occur. In lot 1, for example, 48 nodes dropped their leaves after spraying, 67 per cent of which developed cankers; and in lot 2, out of 132 nodes which lost their leaves after spraying, 74 per cent became cankered. It should also be noted that in lot 2, which received 3 sprays, the number of nodes defoliated by the sprays and the percentage of these developing cankers is much higher than in lot 1 which received only two spray applications. No cankers developed on nodes which retained their leaves throughout the test period, and no cankering was observed on the unsprayed twigs which were artificially defoliated.

It seems evident from these tests that serious nodal cankering may be produced by the use of toxic spray materials and that defoliated nodes are the only ones subject to such cankering. It is evident from the above, however, that a toxic spray may cause both defoliation and cankering. It is seen in blocks 1 and 2 that no cankering was present in 32 and 26 per cent, respectively, of the nodes defoliated by the sprays, thus showing that nodal injury is by no means a prerequisite to defoliation. It would seem that defoliation is due primarily to leaf and petiole injury and that nodal cankering develops later.

Summary

Leaf, twig and 1-year-old wood injury of the peach are very closely correlated with the amount of arsenate of lead in the spray mixture.

Increasing the lime or the sulfur in the mixture has a tendency to reduce the amount of leaf injury but seems to affect the amount of twig cankering to a less extent.

The factors which control leaf injury do not seem to be identical with those that control the amount of wood cankering.

Weather conditions, possibly humidity, seem to determine the amount of injury produced by the several spray applications applied during the season. One season the earliest application and another season the latest application may prove most toxic.

Nodes which have been defoliated from various causes are very subject to cankering. Nodes with leaves attached do not become cankered. A spray application may cause defoliation and subsequent cankering of the defoliated node.

References

(1) Haenseler, C. M. and Martin, William H., 1925 Arsenical injury of the peach. *Phytopath.*, vol. 15, no. 6, p. 321-331.

(2) Farley, A. J. 1924 Spraying experiments with peach. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1924, p. 46-48.

(3) Swingle, B. D., Morris, H. E. and Burke, E. 1923 Injury to foliage by arsenical spray mixtures *Jour. Agr. Res.*, vol. 24, no. 6, p. 501-538.

(4) Adams J. F. 1925 Leaf scar lesions on peach trees. *Trans. Peninsula Hort. Soc.*, vol. 14, no. 3, p. 22-26.

SWEET POTATO DISEASE STUDIES IN 1925

R. F. Poole

The resistance of different varieties of sweet potatoes to stem rot, caused by *Fusarium hyperoxysporum* and *F. batatatis* Wr., was studied again this year. In view of the fact that the disease was more severe this past year than during any of the previous five years, the results of these tests are of considerable value.

The outstanding resistant varieties were the Yellow Yam, White Yam, Red Brazil and Triumph. In previous tests there was no infection of the first three of these varieties and but slight infection of the Triumph. This past year, on Walter Sibkie's farm near Riverton, there was slight infection and kill of the White Yam and Red Brazil varieties. Furthermore, on this farm the production of salable potatoes was not so satisfactory as was produced by the Jersey strains, even though the latter showed heavier stem-rot infection. The potatoes on both the Red Brazel and the White Yam were large and very irregular in the number set to the plant. On this same farm the Yellow Jersey Selection 101, which is used extensively in the state, was more productive of salable stock than the Vineless Yellow Jersey and the Gold Skin. This test shows more definitely than was brought out in other tests that some strains and varieties are much more adaptable to certain soil types than to others.

On Walter Nicholson's farm the results were very similar to those obtained on the farm of Walter Sibkie, but on John Wolferth's farm the yield of the resistant types was not only satisfactory but larger than the strains of Jersey varieties. The results of these tests are given in table 1.

The Red Jersey and Atlantic White, given as Selection 108, showed the greatest stem-rot kill of the Jersey strains. They were also much less productive than some of the other strains.

There was a slight stem-rot kill of the White Yam, Southern Queen and Golden Gem varieties. This is surprising in that these varieties were not attacked during the three previous seasons in which they were grown on infected soils while the Jersey varieties were severely infected. This may

Table 1

A Comparison of Strains of the Jersey Sweet Potato Varieties and Yams on the Farm of John Wolferth, Gloucester County

VARIETAL STRAIN	STEM-ROT KILL	YIELD PER ACRE
	per cent	*bu*
Yellow Jersey, Selection 105	5.2	289
Gold Skin, Selection 116	3.2	264
Yellow Jersey Vineless, Selection 104	1.6	253
Yellow Jersey, Selection 130	5.4	257
Yellow Jersey, Selection 107	1.2	252
Yellow Jersey, Selection 102	2.1	250
Red Jersey, Selection 103	14.1	188
Yellow Jersey, Selection 109	4.1	175
Yellow Jersey, Selection 108	15.8	161
Yellow Yam	0	497
Triumph	0	377
Golden Gem	5.2	308
White Yam	0.1	293
Red Brazil	0	286
Nancy Hall	21.4	260
Southern Queen	2.1	239
Porto Rico	26.5	208

signify that these varieties are becoming less resistant after being grown on infected soils for a number of years.

The Nancy Hall and Porto Rico varieties were again severely attacked and a large percentage of the plants were killed. These results indicate that these varieties are equally if not more susceptible to stem rot than are the Jersey strains. This is not always the case, however, since in some previous tests there was evidence to show that the Porto Rico and Nancy Hall varieties may grow and produce well on some infected soils. There is apparently some unexplained connection with soil type that brings about these differences in the stem-rot kill on the various farms.

The Commercial Value of Varieties of Sweet Potatoes Resistant to Stem Rot

Since the introduction of varieties of sweet potatoes resistant to stem rot, there has been an increase in their production in the areas where the disease is severe. The fact that they are not yet as satisfactory for marketing on the nearby markets and not as productive on all types of soils as are the Jersey strains, has been the most important reason why they are not more widely distributed than they are at the present time. The use of these varieties has increased to such an extent, however, that they are certain to become permanently fixed in some localities. The principal districts where the resistant varieties are being grown in this state are Keyport, Burlington, Swedesboro, Hammonton, and Bridgeport. The Red Brazil is grown extensively in the vicinity of Keyport, and in Burlington County where it is sometimes called the Red Yam and where it is sold in August and early September. The White Yam is grown in the vicinity of Swedesboro and Hammonton. The Red Brazil and Southern Queen varieties are also grown extensively to the east of Hammonton. The Yellow Yam is grown extensively in the vicinity of Center Square and Bridgeport, principally for the early market. In most cases the results of the variety tests were obtained from small plots, so that in order to determine the value of these resistant varieties on a commercial scale, results were obtained this year from larger plantings.

On the farm of John Wolferth the Red Brazil and White Yam varieties have produced excellent crops over a 2-year period when grown on an acre or more of ground. The yields have varied from 250 to 550 bushels per acre. The yields of desirable salable stock was not quite so high, since frequently some large, or "jumbo," potatoes were produced, but as a general rule the larger potatoes could be used and marketed, because they were mostly of the same oval to round shape.

On the farm of Walter Kinney of Swedesboro, the White Yam maintained a nearly perfect stand on infected soils where there was 64 per cent kill of the Yellow Jersey. It also produced 225.6 bushels more per acre than the Yellow Jersey variety, which not only was heavily killed, but showed severe infection of the remaining plants. Furthermore, the White Yam produced a very uniform potato, with very few large potatoes. On this particular farm the potatoes were harvested without any difficulty, although they were not as satisfactory to harvest as the Jersey type, since they were more easily broken from the stems and scattered.

On this farm the value of the White Yam crop per acre was $203.00, and of the Yellow Jersey, $66.01. Where the stem-rot kill of the Yellow Jersey is as great as on this farm, and where the White Yam and other resistant varieties can be grown as successfully, even though they may bring a smaller price than the Yellow Jersey, the increased yield overcomes this drawback. Unfortunately, all soil types are not suited for the production of the resistant varieties, and the only way of determining their value on any soil is to test them at first in a small way.

On the Frank Norton farm at Center Square, where a comparison was made of the Yellow Yam and the Yellow Jersey, some of the former potatoes were large and rather coarse and rough, many of them not being suitable for

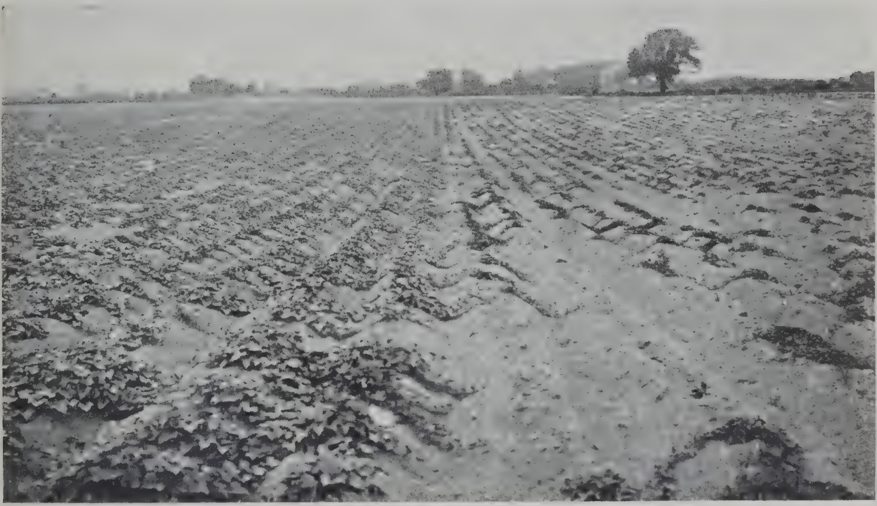


Plate 1. Sweet Potato Field Showing Nearly Perfect Stand of Resistant Yellow Yam on Left, and the Susceptible Yellow Jersey on Right

The misses in the Yellow Jersey field are due to a severe attack of stem rot early in July

(*Facing page* 348)

preparing a fancy package for the market. On the other hand, the Yellow Jersey potatoes were of excellent size, color and shape, and in spite of heavy kill, there was a large production of potatoes of salable size. Furthermore, the Yellow Jersey potatoes were less trouble to harvest than the Yellow Yam. The total yield of the Yellow Yam variety was 385.0 bushels per acre as compared with 225.5 bushels for the Yellow Jersey.

The Residual Effect of Lime and Sulfur on the 'Pox" Disease of Sweet Potatoes

Tests to determine the residual effect of lime and sulfur on pox disease and on the produuction of sweet potatoes, were made on the farms of the late Theodore Jacobs of Swedesboro, and the Vineland Training School at Vineland. The plots used in 1924 were used again in 1925. On the Jacobs farm, plots which received 300 and 600 pounds of sulfur per acre in 1924 were divided into three series. Three plots each received no treatment, three received lime at the rate of 1,000 pounds per acre, and three others, sulfur at the same rates as applied in 1924.

TABLE 2

The Residual Effects of Sulfur and Lime on the Pox Disease and the Production of Sweet Potatoes

Soil Treatment	Amount used per acre	Potatoes poxed	Yield per acre
	bushels	*per cent*	*bushels*
Sulfur	100	13.3	130
Sulfur	200	11.3	140
Sulfur	300	0.0	149
Sulfur	400	0.2	173
Sulfur	600	0.0	144
Lime	1000	100.0	57
Lime	2000	100.0	53
Lime	3000	100.0	70
Check	....	41.3	103

The applications were made one month previous to setting the sprouts and there was one rain before the crop was set the last week in May. The plants had been set only a few days, when a severe hail-storm cut them up severely. The black-rot infection that followed also was severe. The drought during the early months delayed the growth to such an extent that the production was far below normal. The results obtained on this farm show that the disease was not satisfactorily controlled by sulfur, even when 300 and 600 pounds of sulfur were used on the same soil in both 1924 and 1925. This treatment, however, gave some reduction, and was much more effective than where sulfur was used only in 1924, since the residual effect showed only slight reduction over the check. On the untreated and limed plots the disease was worse than it was on the sulfured plots. The disease was worse on the plots that received no treatment in 1924 and lime in 1925. There was no indication of plant or potato injury on any of the plots, even where 600 pounds of sulfur was used both years.

It is interesting to compare these findings with those from the Vineland Training School farm, where plots treated with sulfur or lime in 1922, 1923, and 1924 were used in 1925 without further treatment. The production was smaller on the limed plots in 1923 and 1924 than on the untreated and sulfured plots and again in 1925 the plants were injured from the very beginning on the limed plots. They were yellow and weak until late in the summer when the moisture was more favorable for growth. The vines which had not died grew well later in the season, but the growth was not early enough to produce a crop of salable potatoes. No such condition occurred on the untreated and sulfured soils; instead the vines were green and sufficiently numerous on all plots to indicate a fair production. The results given in table 2 show that sulfur reduced the disease 28 per cent where 100 pounds was used each year for three years. Where 200 pounds was used there was a further slight reduction over the 100 pound treatment. Where 300, 400 and 600 pounds were used there was no infection. The infection was 100 per cent on the limed plots, most of the salable potatoes showing many spots.

The effect on yields was much greater than ever seen before when these treatments were compared on pox-infected soils. The yields on the sulfured plots were from 9 to 40 bushels larger where 300, 400, and 600 pounds of sulfur had been used than where the smaller amounts were used, but the differences were not sufficiently great to warrant the use of more than 300 pounds per acre. As a result of pox control, 100 pounds of sulfur per acre applied for three consecutive years increased the yields 27 bushels over the untreated plots. Lime caused a reduction in the yield of 33 to 50 bushels per acre.

The results reported above support those obtained in other years. They show that it is difficult to bring pox-infected soils back to normal production, especially where lime was applied in large quantities. The results have shown also that sulfur is most effective in wet seasons, and slowly effective in dry seasons and that the disease is most severe in dry seasons. However, the use of sulfur apparently reduces the conditions most suitable for infection, while lime enhances those conditions.

The Effect of the Potash Salts on the Yield of Sweet Potatoes and the Stem-Rot Disease

Previous studies have shown that large amounts of fertilizer caused severe injury to sweet potato sprouts, and the losses due to stem rot were greater on the injured than on the uninjured plants.

Further tests were conducted this year in which kainit and sulfate and muriate of potash were used to supply 7 per cent of potash in a mixture containing 2 per cent of nitrogen and 8 per cent of phosphoric acid. This mixture was applied broadcast in the row 6 weeks before the crop was set the first week in June. Besides broadcasting the fertilizer in the row, it was well mixed with the soil before the ridges were made. This test was conducted on the Vineland Training School farm, and on the farm of Seth Warrington in cooperation with Dr. H. C. McLean of this station.

The results obtained on the Warrington farm, given in table 3, show that the injury and the kill by stem rot were much greater where the mixture

TABLE 3

The Effect of Potash Salts on Yield and on the Prevalence of the Stem-Rot Disease

Source of Potash	Amount of fertilizer used per acre	Plants killed by stem rot	Plants missing due to injury	Yield per acre
	lbs.	*per cent*	*per cent*	*bu.*
Kainit	500	27.2	27.2	54.0
Kainit	1000	41.5	38.2	33.7
Muriate	500	23.4	13.1	122.6
Muriate	1000	36.0	8.4	120.5
Sulfate	500	22.9	8.6	152.2
Sulfate	1000	21.4	7.4	128.9
None	500	17.0	10.3	121.7
Check	....	25.8	10.5	131.1

containing kainit was used instead of the other potassium salts. The figures on the missing hills are the sum of the percentage of plants killed by stem rot and of the plants killed by the fertilizer. It can be seen from these results that the kainit was fatal to a very large percentage of plants, since there were very few left even where only 500 pounds of the fertilizer was used. There were slightly more misses on the plots that received the mixture containing muriate than on the check plots, but the difference was not outstanding. The percentage of stem rot on the other treatments varied from 7.4 to 12.5.

The yields were greatly reduced on the plots where kainit was used, being 77.1 and 97.4 bushels per acre less than was obtained on the check plots. On the untreated plots and on the plots that received the mixture of nitrogen and phosphoric acid, the production was as good as from the other treatments, since the field was already sufficiently fertilized for a maximum production of the sweet potato. A normal growth was not obtained during the early part of the summer because of drought. Favorable growing conditions prevailed late in the summer, but this caused a production of a very large number of small potatoes which were not sufficiently large to market by harvest. On the various plots much of the fertilizer was turned up when the plants were harvested.

There was much evidence in many fields of the general crop that the potash salts had caused considerable injury to the plants. The nature of the injury was nearly always manifest as a mottling or spotting of the leaves. Plants that showed the dwarfed, mottled symptoms did not always at first have any noticeable injury to the roots, but some plants showed a softening and blackening of not only the small roots, but the main stem also. It is well known that the Fusaria fungi enter injured tissue much more readily than healthy tissue. This probably accounts for the greater prevalence of stem rot on plots where the plants were injured by kainit than on those where sulfate and muriate of potash were used.

As has been pointed out in previous reports, any and all of these sources of potash can be used safely, if applied several months previous to setting the plants.

The Effect of Sulfur and Lime on the Scurf Disease of Sweet Potatoes, on the Plant and on Production

In 1924 very uniform areas were selected on the farms of J. I. Little at Vineland, and Felix Donata at Landisville, for determining the effects of sulfur and lime on the scurf disease and on the yield of sweet potato. The results obtained on both farms were relatively the same. The results given here are those obtained on the Donata farm. The area of each plot was 1/75 acre. In 1924 there were twenty replications of each treatment. The treatments that year were with 300 and 600 pounds of sulfur per acre and the results were given in the 1924 report.

The same plots were used again in 1925 and were given the following treatment one month before the plants were set. Four plots used as checks in 1924 were left for checks in 1925. Four plots each that received 300 and 600 pounds of sulfur per acre in 1924 received the same amounts in 1925. Three plots each that received no treatment, 300 pounds of sulfur, and 600 pounds of sulfur respectively in 1924, received 1,000 pounds of lime per acre in 1925. Four plots that received 300 and 600 pounds of sulfur in 1924 did not receive any further treatment for 1925.

The 1924 results showed that the disease was greatly reduced with sulfur, but the 600 pounds per acre caused severe damage to the sprouts. In 1925 the objects were to determine what effects applications of sulfur for two or more consecutive years, would have on the disease and on yield, and whether or not the treatment in 1924 would be sufficient to prevent infection in 1925. And finally it was desired to determine the effect of lime on sulfur-treated soil as well as upon the disease and production.

The results obtained in 1925 are given in table 4. They show that there was an increase of 8.3 to 10.3 per cent of infected potatoes when lime was used. This was true, even where the sulfur was applied last year. The scurf disease is not thought to affect yields, but the limed soil for some reason showed yield decreases of 19 to 56 bushels per acre as compared with the sulfured and the untreated soil. There was no apparent injury to the vines or potatoes on the sulfured plots on this farm, but injury similar to that described in last year's report was observed on the Little farm. The vine growth was not as good on the limed plots as on the untreated plots and there was some indication that the growth of the plants was retarded. There was also slight evidence of chlorosis of the foliage.

TABLE 4

The Effect of Sulfur and Lime on the Scurf Disease, and on the Yield Per Acre

Treatment		Amount per acre	Potatoes scurfed	Yield per acre
1924	1925			
		bu.	*per cent*	*bu.*
Check	Check	0-0	9.6	133
Check	Lime	0-1000	17.9	114
Check	Sulfur	0-300	2.2	141
Sulfur	......	300-0	11.4	126
Sulfur	Lime	300-1000	19.9	108
Sulfur	Sulfur	300-300	8.5	118
Sulfur	......	600-0	11.8	118
Sulfur	Lime	600-1000	17.7	77
Sulfur	Sulfur	600-600	0.6	121

In this test the production on the plots treated with 300 pounds of sulfur in both years was 15 bushels less than on the untreated plots, while on the 600-pound plots it was 12 bushels less. On the plots that were not treated in 1924, but treated with 300 pounds of sulfur in 1925, there was not only a reduction of 7.4 per cent in the percentage of infected potatoes, but a yield increase of 8 bushels over the untreated plot. These results indicate that caution should be taken when sulfur is to be used over a period of consecutive years, since it may cause injury.

Although there was a much smaller percentage of scurf infection in 1925 than in 1924, the results obtained thus far indicate that 300 pounds of sulfur, on the sandy soils will reduce the amount of the disease but the treatment for only one year may not be effective the next year. Applications of 300 and 600 pounds per acre over two consecutive years reduced the disease, but caused a slight reduction in the yield, which was obtained only on the plots treated with 600 pounds of sulfur in 1924. On both farms the use of lime reduced the yield, and there was an indication of chlorosis of the foliage.

The Effect of Organic Mercury Compounds, Mercuric Chloride, and Formaldehyde on the Control of the Scurf or Soil Stain Disease of Sweet Potatoes

While it is easy and economical to obtain sweet potatoes for seed that are free from the very conspicuous superficial scurf disease, there are some growers who do not recognize the importance of seed selection, and who depend unwisely on seed treatment for the control of such diseases as scurf. It has been well demonstrated that recommended treatments with formaldehyde and mercuric chloride are not 100 per cent effective in killing the scurf fungus on the potato. Furthermore, it is now certain that when the causal organism is not controlled completely, it respreads over the skin of the potato while in the plant bed. Scurf is most difficult to control when the potatoes are severely diseased, since the effectiveness of the treatments on slightly infected potatoes is generally satisfactory.

Because of the introduction of the organic mercury compounds as seed disinfectants and because of the importance of the scurf disease of sweet potatoes, some tests were conducted with DuPont Semesan, Uspulun and Bayer Compound, and comparisons were made with the treatments now recommended. The organic mercury compounds were used both as liquid and as dust treatments. The Yellow Jersey selection No. 105 was used in the test. Uniform potatoes measuring approximately 3 inches long and 2 inches wide and completely blackened with the scurf disease were obtained for this work. They were treated with dust compounds at the rate of 2 ounces per bushel. The potatoes and dust compounds were placed together in a large paper bag which was tilted back and forth until the surface of the potato was completely covered. The liquid treatments were prepared by dissolving the chemicals in water at a temperature of 50° C., and then diluting to the recommended strength of 1-400. The treatments were for various periods of time at a temperature of 18° C. After treating, the potatoes were bedded in washed sand in 12-inch glazed earthenware pots and were kept in a greenhouse where the temperature maintained was sufficient to develop the sprouts.

Preliminary tests were started in February, but larger tests were begun in March, April and June. The preliminary tests were conducted primarily to determine the effect of the various substances on plant growth, when used in the strengths that are now being recommended by the various manufacturers. The 1-1000 strength of mercuric chloride was employed while formaldehyde was used at a strength of 1-240. The time was 10 minutes for all liquid treatments. In other tests the same strengths were used, but the time of treatment was varied. There were two replications of each treatment, and three series of treatments, including the preliminary test.

The results from the disinfectants when used in solution, given in table 5, show that none were very effective. The formaldehyde gave the least control of all when the treatment was carried out for 20 minutes. The 30-minute treatment was somewhat more efficient than the shorter time, but it, too, was not as effective as is needed. The results obtained with mercuric chloride were very irregular, and they indicate that satisfactory control of scurf may not be expected with the present recommendation for seed disinfection. It must be remembered, however, that there are several other fungi that cause diseases of the sweet potato that the mercuric chloride will kill. The results

TABLE 5

Effect of Liquid Disinfectants on the Control of Scurf

Disinfectant	Strength	Time treated	Infection of plants harvested in October from treated potatoes	Diseased potatoes, plants harvested in May, potatoes harvested in October
			per cent	*per cent*
Check—healthy plants.	....	..	0	0
Check—diseased plants	....	..	100.0	100.0
Formaldehyde	1-240	20	100.0	100.0
Mercuric chloride	1-1000	10	65.2	39.7
DuPont Semesan	1-400	10	33.3	30.0
Bayer Organic Mercury	1-400	10	63.6	32.5
Bayer Uspulun	1-400	10	29.5	25.1

obtained with Uspulun, a phenol mercury which was obtained from the Bayer Chemical Company, was slightly more effective than the Bayer Dust, mercuric chloride and the solutions of Semesan obtained from the E. I. DuPont Company. All of the mercury compounds showed a greater degree of control on the potatoes which were grown from sprouts pulled in May than on the sprouts pulled from the same plantbed in October. The differences were sometimes 50 per cent greater infection than on the potatoes. This is probably due to the fact that the plants which were used for securing the data on the potatoes were pulled six weeks after the treatments were made. The others were pulled in October, after the plants had remained in the plantbed since March. The conditions in the plantbed are known to be very favorable for the reinfection of the potatoes when the organism is not killed on all parts of the potato. From March until October the disease had completely respread over the potatoes in some cases, which accounts for the greater prevalence of the disease on the sprouts pulled in October instead of May. The fungus on slightly infected potatoes was easily killed by the treatments with mercuric chloride, formaldehyde, Semesan and Uspulun.

The effect of disinfectants on the control of scurf when used as a dust was outstanding. Two ounces of the dusts left a fine white coating on the rind, which lasted throughout the time that the potatoes were in the plantbed. In many cases the potatoes in the plantbed had produced new growth which gave the old potato a warty appearance, and it was on these new growths that the disease was most conspicuous. The growths on the treated potatoes were free of scurf, while that on the untreated potatoes was generally as black as that of the original diseased potato. The same condition was manifest on the sprouts. The results of the dust treatment, in which Semesan manufactured by the DuPont Company and another organic mercury produced by the Bayer Company were used, are given in table 6 and they show that the Semesan completely controlled the disease, the sprouts as well as the potatoes produced on them being free from scurf. There was a very slight infection of the sprouts where the Bayer Compound was used, slightly greater on the sprouts which were pulled in October, than on the potatoes grown on the sprouts pulled from the same potatoes 6 weeks after treatment and set in the field. There was no infection on the sprouts grown on the disease-free potatoes, and the potatoes produced in the field on these sprouts also were free from scurf.

These results show that the dust treatments were much more effective in the control of scurf than were the liquid treatments. It is obvious that they should be equally as efficient as the liquid treatments since the dusts adhered to the rind throughout the period that the potatoes were in the plantbed, while very little of the material was left on the potato after the liquid dip. The possibilities of the respread of the fungus on the potatoes treated in the solution was much greater than on those treated with the dust.

Table 6

The Effect of Dust Disinfectants on the Control of Scurf

Disinfectant	Amount used per bushel	Infection on sprouts pulled from treated potatoes in October	Infection on sprouts pulled from treated potatoes in May and potatoes harvested in October
	oz.	*per cent*	*per cent*
Check—Healthy plants	..	0	0
Check—Diseased plants	..	100.0	100.0
DuPont Organic Mercury	2	0.0	0.0
Bayer Organic Mercury	2	10.0	4.0

In laboratory tests in which the fungus was grown in culture media adjusted to various strengths with mercuric chloride, the organic mercury compounds and formaldehyde showed that all of the organic mercury compounds contained the active killing agent. Semesan was the most effective of the organic compounds. Mercuric chloride was also very effective. Some of the compounds gave poor control, even when used at the strength recommended for seed treatment.

While some of the organic mercury dust treatments gave excellent control, they caused considerable injury to young roots. All of the organic mercury compounds, as well as mercuric chloride to a lesser degree, caused a retardation of the development of the sprouts, and in some instances prevented their development. For this reason the conditions under which this injury occurs and other phases of correcting the toxicity of the chemical, should be given further study before the organic mercury compounds will become entirely satisfactory. In the meantime, the mercuric chloride treatments should be continued for the control of other parasitic fungi that are harbored on the sweet potato. The most efficient control of scurf, however, is easily obtained by the use of disease-free seed, as is clearly shown in the results given above, since they indicate that a clean crop of potatoes will be obtained when healthy plants are used on uninfected soils.

Report of the Department of Plant Physiology

John W. Shive

Work on the projects in the department of plant physiology has been continued during the year and several new studies have been undertaken. From time to time throughout the year results have been published, and the following papers contain data on three of the investigations under way.

EFFECTS OF BORON ON THE GROWTH OF VICIA FABA IN CULTURE SOLUTIONS

A. B. Fagundes

The study of the mineral composition of vegetable matter has led several investigators to consider the possible existence of many elements necessary to plant growth aside from those commonly accepted as essential. Among those which have been thought by some authors to be indispensable to certain plants, one element, boron, in recent years has been occupying the attention of plant physiologists. That boron is a constituent of plant material was known to Wittstein and Apoiger in 1857, after their studies on the composition of a species of Primulaceae. Since then the presence of boron has been detected by several workers in a great variety of plants comprising a large number of families. Since the beginning of the present century, many physiologists have been experimenting with boron as a stimulant for plant growth. Among the more important contributions to the subject are those of Agulhon (1, 2, 3) in France, and those of Brenchley (4, 5, 6) and Warington (9) in England.

Agulhon, after detecting the presence of boron in several plants and plant products, failed to observe any stimulation caused by boron on the growth of yeasts, lactic ferment, and *Aspergillus niger*. He observed marked stimulation in the case of wheat and oats grown in water cultures, as well as in sand cultures. He also found a favorable effect on the action of some enzymes, and concluded by classifying boron as a "particular element" which probably acts as a catalyst, indispensable to certain groups of organisms, which by force of a long heredity have been adapted to live under particular conditions.

Warington, after a long series of experiments on the nutrition of *Vicia faba*, does not accept the view of Agulhon, on the grounds that this element is required, although in minute quantities, in all stages of the growth of this legume. In the constant need of small amounts of boron throughout the life of certain plants, Warington sees a possible analogy between the function of this element in plant life and the function of vitamins in animal life.

Brenchley and Thornton (6), in a recent investigation on the development, structure, and functioning of nodules on *Vicia faba* as influenced by the presence of boron, have noticed in the plants deprived of that element a defective vascular supply of the nodules, accompanied by an abnormal development of these and by reduced nitrogen fixation. According to the authors, this insufficient vascular supply of the nodule, probably by causing a reduction of the carbohydrate material available to the nodule organisms, would be responsible for the tendency shown by the bacteria to become parasitic and attack the protoplasm of the host cells for their supply of energy.

The purpose of the work carried on at this laboratory on the question of boron stimulation, of which the present article is merely a preliminary report, involves an investigation on the generality of the responses to boron application and a study of the nature of these responses.

The Rothamsted culture solution, which has been used in the work conducted by Warrington (9), has the following composition:

KH_2PO_4	0.5 gm.	$MgSO_4$	0.5 gm.
KNO_3	1.0 gm.	$FeCl_3$	0.04 gm.
NaCl	0.5 gm.	$CaSO_4$	0.5 gm.

Distilled water to make up to a liter.

For the sake of comparing the effects of boron in two different culture solutions, identical concentrations of this element were supplied as boric acid to plants growing in the Rothamsted culture solution of the above composition, and to plants growing in the Modified Tottingham solution (7), a Tottingham solution $T_3R_1C_4$ (8) in which the KNO_3 is replaced by $(NH_4)_2SO_4$ in an isosmotic concentration. The molecular concentrations of the components of this solution, which has a total concentration corresponding to one atmosphere osmotic pressure, are as follows:

KH_2PO_4	.00624
$MgSO_4$	.00464
$Ca(NO_3)_2$	.00576
$(NH_4)_2SO_4$	.00135

An aqueus solution of ferrous sulfate was added in small quantities to the culture solution only as the plants by their color and general appearance showed that they required iron.

Selected seeds of *Vicia faba* were germinated in damp sphagnum moss, where they were kept for about ten days before the seedlings were placed in the different solutions. These were contained at the beginning in 1-liter Erlenmeyer flasks of Pyrex glass; but in view of the fact that the roots of some plants acquired a very large volume, it was thought advisable to change all the plants to 2-quart jars.

Nineteen days after the plants were placed in the solutions, some marked influences of the presence of boron could be observed in the development of the plants grown in the Rothamsted solution. The plants grown in this solution to which no application of boron had been made were very much retarded in growth, but the plants in the treated cultures showed an apparent correlation between the amount of boron applied and the development of the shoots. More striking effects, however, were noticeable in the development of the roots. The plants deprived of boron, and to a lesser extent those to which boron has been supplied in the concentration of 1 : 100,000,000 produced roots which were stunted and stubby in appearance with very few and very short lateral branches; whereas the plants growing in the solutions to which boron had been added produced an abundance of long fibrous roots. At the same stage of development, the plants grown in the Modified Tottingham solution treated with boron did not show any markedly stimulating effects of this element so far as the growth of tops was concerned. The development of the roots, however, was much better than in the cultures without boron, the long fibrous growth contrasting sharply with the stubby appearance of the roots of the check plants. It is important to emphasize here that the Modified Tottingham solution $T_3R_1C_4$ produced more vigorous and healthy *Vicia faba* plants than did the Rothamsted solution during the early phases of development. As a matter of fact, the Rothamsted solution as here used proved to be a rather poor medium for the early growth of this plant, and for this very reason, perhaps, the stimulating effect of the boron treatments was quite pronounced. The Modified Tottingham solution, on the other hand, produced excellent plants which, because of their vigorous healthy condition, failed to show the marked response to the boron treatment exhibited by the less vigorous plants grown in the Rothamsted solution. It is interesting to note also that the plants grown in the Modified Tottingham solution containing boron required higher concentrations of ferrous sulfate to maintain the normal green color than did the plants grown in this solution without boron. The reason for this apparently higher iron requirement is at present not clear.

The data in Table 1 show some of the results obtained with the two sets of cultures. In spite of the irregularity of these data they indicate that, under the conditions of the experiment, there was a decided influence of boron on the development of both tops and roots of the broad bean plant. It will be observed that the yields from the Modified Tottingham solution are in no case less than double the corresponding yields from the Rothamsted solution, and these differences in yields are by no means offset by the differences in the age of the plants when harvested, since the superiority was quite readily observed from the beginning of the experiment, as previously noted.

TABLE 1

Relative Dry Weights of the Yields of Vicia Faba Grown in the Rothamsted Solution and in the Modified Tottingham Solution $T_3R_1C_4$ *With Varying Amounts of Boron as Boric Acid*

H_3BO_3	ROTHAMSTED SOLUTION				MODIFIED TOTTINGHAM SOLUTION			
	Tops	Roots	Total	Ratio Tops / Roots	Tops	Roots	Total	Ratio Tops / Roots
p.p.m. 0	1.00 (0.920 *gm.*)	1.00 (0.170 *gm.*)	1.00 (1.090 *gm.*)	5.41	1.00 (3.220 *gm.*)	1.00 (1.00 *gm.*)	1.00 (220 *gm.*)	3.22
0.01	1.234	0.706	1.151	9.46	1.144	0.910	1.089	4.05
0.08	0.962	1.029	0.972	5.06	1.270	1.040	1.216	3.93
0.40	2.065	3.735	2.159	.2.99	1.165	1.545	1.255	2.43
2.00	1.772	3.059	1.972	3.13	0.994	1.160	1.033	2.76
10.00	2.125	3.059	2.271	3.76	1.168	1.405	1.224	2.68
20.00	2.060	2.941	2.197	3.79	1.458	1.450	1.361	3.24
40.00	1.935	2.176	1.972	4.81	1.136	0.950	1.084	3.82
200.00	1.250	1.471	1.284	4.60	1.140	1.200	1.154	3.06

Rothamsted Solution	Modified Tottingham Solution
Set to germinate March 16...... 9 days	Set to germinate March 16 ....10 days
Placed in solution March 25.....25 days	Placed in solution March 26 ....34 days
Harvested April 19..............34 days	Harvested April 29 ....44 days

Increase in total yield of dry plant substance over that produced by the check cultures due to the low applications of boron to the culture solutions is clearly expressed by the relative numbers in columns 4 and 8 of table 1. There is some indication that the optimum concentration of boric acid for both solutions lies between 10 and 20 p.p.m. The Rothamsted solution which produced the maximum total dry weight yield contained 10 p.p.m. boric acid. The average total yield from this solution was 127 per cent higher than the corresponding yield from the check cultures. The average maximum total yield of dry plant substance produced by the Modified Tottingham solution occurred with 20 p.p.m. boric acid and was 36 per cent higher than the corresponding yield from the check cultures. The relative superiority of yields from boron-treated cultures over those from the corresponding checks was very much greater for the Rothamsted solution than for the Modified Tottingham solution, thus indicating that the stimulating influence of boron upon the growth of these plants is much less pronounced in a solution which produces good growth than in a solution which produces relatively poor growth. If to this is added the fact that at the beginning of the experiment the differences between the plants grown under different boron concentrations were more marked in the

Rothamsted solution than in the Modified Tottingham solution, there appears to be a strong suggestion that the effects of boron upon the growth of this plant are somehow accentuated by, if not entirely due to, certain conditions which are inherent in the culture solution itself.

It is to be expected that in some culture solutions the stimulating effects of boron would quite probably be even more accentuated than those which have been observed in connection with the Rothamsted solution. On the other hand, in culture solutions best adapted to the growth of this plant, it is entirely possible that boron could exert no stimulating influence, but only an injurious one and could, therefore, not be regarded as an essential element for growth nor as possessing a specific function. This, however, remains to be demonstrated.

References

(1) Agulhon, H. 1910 Recherches sur la présence et le rôle du bore chez les végetaux. These presentée á la Faculte de Sciences de l'Université de Paris.

(2) Agulhon, H. 1910 Emploi du bore comme engrais catalytique. *Comp. Rend. Acad. Sci. (Paris)* 150:288-291.

(3) Agulhon, H. 1910 Accountumance du maís au bore. *Compt. Rend. Acad. Sci. (Paris)* 151:1382-1383.

(4) Brenchley, W. E. 1914 Inorganic Plant Poisons and Stimulants, p. 65-77. Cambridge Univ. Press.

(5) Brenchley, W. E. 1914 On the action of certain compounds of zinc, arsenic, and boron on the growth of plants. *Ann. Bot.* 28:283-301.

(6) Brenchley, W. E., and Thornton, H. G. 1925 The relation between the development, structure and functioning of the nodule on *Vicia faba,* as influenced by the presence or absence of boron in the nutrient medium. *Proc. Roy. Soc.* 98:373-399.

(7) Jones, L. H., and Shive, J. W. 1921 Effect of ammonium sulfate upon plants in nutrient solutions supplied ferric phosphate and ferrous sulfate as sources of iron. *Jour. Agr. Res.* 21:701-728.

(8) Tottingham, W. E. 1914 A quantitative chemical and physiological study of nutrient solutons for plant cultures. *Physiol. Res.* 1:133-245.

(9) Warington, K. 1923 The effect of boric acid and borax on the broad bean and certain other plants. *Ann. Bot.* 37:629-672.

ABSORPTION OF NITROGEN FROM CULTURE SOLUTIONS BY PLANTS

C. D. JONES AND C. E. SKINNER

The literature pertaining to the subject of the relative availability of nitrate and ammonium salts has been reviewed by Hutchinson and Miller (3) and by Jones and Shive (4). Earlier work has shown that the ammonium and the nitrate ion are each assimilated by plants, and that growth is promoted by both forms of nitrogen. Either form may serve as a sole source of nitrogen for many plants, but in general the plants grow best when supplied with nitrates. It was found, however, that plants grown in solutions or soil contained more nitrogen per unit of dry weight when the nitrogen was supplied as ammonium salts.

Much of the earlier work with solution cultures in this connection was carried on for very short periods of time, or else the solutions were left unchanged for long periods. As has been shown by Jones and Shive (4) the reaction of a solution is changed very rapidly toward the basic range when nitrogen is supplied as $Ca(NO_3)_2$, and becomes more acid when $(NH_4)_2SO_4$ is the form of nitrogen used. In other words, the change in pH of a nutrient solution is conditioned by the differential absorption of ions. Even a few hours of contact of plant roots with solutions made a distinct change in the pH of a solution. For this reason it is not certain that the superior growth of plants in solutions containing nitrates over those grown in solutions containing only ammonium salts is not due to different hydrogen-ion concentrations after six weeks of contact with the roots.

Prianishnikov (6) in some recently published results covering several years' experimental work, indicates that ammonium salts proved to be a better source of nitrogen for vetch and maize in the early stages of growth than did nitrates. The reaction of the solution was controlled by the addition of $CaCO_3$, by frequent renewal of solution, or by the use of NH_4HCO_3 as a source of ammoniacal nitrogen.

Jones and Shive grew wheat (4) and soybeans (5) in balanced solutions containing nitrogen in both ammoniacal and nitrate forms, and in similar solutions in which KNO_3 replaced the $(NH_4)_2SO_4$. The solutions were renewed twice a week. The plants grown in the solutions containing ammonium ions were uniformly better than the plants which depended upon nitrates alone for their nitrogen, provided the iron supply was adequately controlled. Prince, Jones, and Shive (7) have shown that soybeans in the early stages of growth absorb more nitrogen from solutions containing both ions. Here again the absorption of the ammonium ions was correlated with an increase in the acidity of the solution.

The work which is here presented was designed to show the actual and relative amounts of nitrogen withdrawn by plants during definite short intervals throughout the whole growth cycle from frequently renewed, balanced culture solutions containing both ammonium and nitrate ions.

Experimental

Soybeans were germinated in sphagnum moss, and uniform seedlings were transferred to jars containing the culture solution. The culture medium for the first two series was the Modified Tottingham Solution (8), $T_1R_1C_5$, containing $(NH_4)_2SO_4$, $Ca(NO_3)_2$, KH_2PO_4, and $MgSO_4$ in the following volume-molecular proportions: 0.0014, 0.0073, 0.0021, and 0.0071, respectively.

Ordinary 2-quart fruit jars of colorless glass were used as culture vessels. Each contained three plants mounted in a 2-piece cork stopper as designed by Tottingham (8). The solutions were renewed by the daily addition of 1 liter of fresh solution, according to the "drip and drain" method of Allison and Shive (1). The cultures were aerated at all times by bubbling air through the solutions.

At the end of every second week, beginning with the third week after the plants were transferred to the jars, the absorptive action of the plants was ascertained in the following manner: a series of small jars each containing 400 cc. of the culture solution was prepared. The plants growing in the culture vessels were then transferred to the small jars by simply transferring the cork stopper in which the plants were mounted from one to the other jar. They were there allowed to remain for periods of time ranging from 4 to 48 hours, whereupon they were returned to the original jars. The nitrogen composition in the small jars was then determined by the procedure recommended by the Standard Methods for Water Analysis (2), except that the standards were made from the original solution and a Duboscq colorimeter replaced the comparator tubes. For the later experiments, a more accurate method of determination was used, which will be given in detail in a following section.

The manner in which these experiments was carried out would probably eliminate any possibility of nitrification. The initial reaction of the culture solution was approximately pH 4.8. This alone should prevent the activity of any nitrifying organisms which might be present. Furthermore, the short periods of exposure (never more than 48 hours) would also elminate this possibility.

Table 1 shows the amounts of nitrogen in both nitrate and ammoniacal form which were removed by the three plants from 400 cc. of solution containing 39.2 mgm. of ammonia nitrogen and 204.4 mgm. of nitrate nitrogen per liter (p.p.m.) at the start.

The table indicates that both forms of nitrogen are utilized, but it appears that the plants absorbed only ammonium nitrogen at the 3-week stage of growth. This can not be asserted positively, however, since the method of analysis employed was not sufficiently sensitive to measure very small differences in nitrate

TABLE 1

Ammonium and Nitrate Nitrogen Removed from 400 cc. Modified Tottingham Solution $T_1R_1C_5$ by Three Soybean Plants of Different Ages and for Various Periods of Time—Series 1

Time of contact of roots with solution	PLANTS 3 WEEKS OLD		PLANTS 5 WEEKS OLD	
	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter
hours	*mgm.*	*mgm.*	*mgm.*	*mgm.*
4	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
12	2.9	0.0	3.9	0.0
16	0.0	0.0	3.9	25.6
28	0.0	0.0	7.4	25.6
36	11.8	0.0	7.4	51.1
48	14.7	0.0	13.5	81.8

content. Certainly, however, the plants did not absorb relatively nearly so much nitrate from solution during an experimental period at the end of 3 weeks as they did at the end of 5 weeks. It will be observed also that at the end of the 5-week period of growth, the plants absorbed nitrate nitrogen at a considerably higher rate than they did ammonium nitrogen; a condition just the reverse of that which prevailed when the plants were 3 weeks old.

These plants were grown during the months of June and July and attained a very large size for plants of this age. The experiment was repeated in greater detail during a cool, cloudy autumn season, and was continued until the plants reached maturity (9 weeks after the plants were placed in the solutions). These plants were not so large as those of the preceding experiment, averaging 13.26 gm. in dry weights of tops per culture, but they were very healthy and were entirely normal in appearance. The results of this experiment are given in table 2.

The data of this series show that ammonium nitrogen is absorbed from solution throughout the life of the plant and at somewhat similar rates. It was only during the later stages of growth, however, that nitrate nitrogen was absorbed from solution in amounts large enough to be detected by the method of analysis employed.

The data of series 1 and 2 indicate that ammonium nitrogen is readily absorbed from solution by the soybean plant at all times, even when the nitrate nitrogen content of the medium is several times as great as the ammonium nitrogen content. The data do not indicate definitely at what stage of development the plants begin to absorb nitrate nitrogen at significant rates, nor do they show what might be the relative rates of absorption of nitrogen in the two forms when they are present in the medium in somewhat equal proportions. To answer this question, the experiment was repeated with modifications during the following season (May-June, 1925). Here the plants were grown in solutions containing approximately the same amounts of ammonium and nitrate nitrogen. Intermittent solution renewal was substituted for the drip and drain method employed in the preceding series. The solutions were renewed twice a week. In addition to soybeans, a pure line maize was also grown. Unfortunately, excessive heat necessitated the discarding of the soybeans after 3 weeks' growth and the corn after 6 weeks. Up to this time, however, the plants were very vigorous and healthy.

The methods of analysis used were as follows: the 400 cc. of solution was washed into a 1-liter flask, made up to volume and then divided into two equal portions and poured into Kjehldahl flasks. Then 5 cc. of 50 per cent KOH

TABLE 2

Ammonium and Nitrate Nitrogen Removed from 400 cc. Modified Tottingham Solution $T_1R_1C_5$ by Three Soybean Plants of Different Ages and for Various Periods of Time—Series 2

Time of contact of roots with solution	PLANTS 3 WEEKS OLD		PLANTS 5 WEEKS OLD		PLANTS 9 WEEKS OLD	
	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter
hours	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
4	0.0	0.0	0.0	0.0	2.9	0.0
8	0.7	0.0	3.6	0.0	4.2	0.0
12	3.6	0.0	6.6	0.0	2.9	9.7
16	4.1	0.0	7.0	0.0	4.2	9.7
20	4.1	0.0	8.9	0.0	4.2	14.3
24	6.4	0.0	11.2	0.0	4.2	14.3
28	5.0	0.0	15.8	0.0	5.4	14.3
32	4.6	0.0	16.8	0.0	5.4	30.4
36	5.6	0.0	16.8	0.0	8.6	50.1
40	6.4	0.0	17.4	0.0	9.5	34.1
44	9.5	0.0	17.4	0.0	13.4	63.4
48	9.7	0.0	18.0	0.0	14.7	76.7

TABLE 3

Ammonium and Nitrate Nitrogen Removed from 400 cc. Modified Tottingham Solution $T_1R_1C_1$ by Three Soybean Plants and from 400 cc. Solution $T_3R_1C_1$ Containing the Same Amounts of Ammonium and Nitrate Nitrogen by Three Maize Plants of Different Ages and for Various Periods of Time (Average of Two Cultures)—Series 3

Time of contact of roots with solutions	SOYBEANS 3 WEEKS OLD		MAIZE			
			3 WEEKS OLD		5 WEEKS OLD	
	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter	Nitrogen as NH_4 removed per liter	NO_3 removed Nitrogen as per liter	Nitrogen as NH_4 removed per liter	Nitrogen as NO_3 removed per liter
hours	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
4	2.4	0.0	3.5	0.0	4.5	14.7
8	4.2	4.2	4.2	0.0	12.6	20.3
16	5.6	4.5	4.9	0.0	23.2	34.3
24	8.4	6.7	7.7	3.5	29.4	36.0
48	12.1	17.6	10.5	9.1	38.5	37.8

was added and the solutions were distilled. The distillate was collected in standard acid and the amount of NH_4 nitrogen was determined by titration. The residue was cooled, water and Devarda's alloy were added to reduce the nitrates to ammonia. The distillate was collected and titrated as before. This was taken to represent the nitrate nitrogen. The results obtained from duplicate cultures checked closely and were averaged. Data of the analyses are given in table 3.

These data show again that both ammonium and nitrate nitrogen are simultaneously absorbed by the rapidly growing plants. In this series the soybean plants began to absorb nitrate nitrogen in significant amounts at an earlier period than did those of the preceding series, no doubt because the plants of this series developed at a very rapid rate. The corn plants at the end of the 3-week period were still absorbing ammonium nitrogen at a considerably higher rate than nitrate nitrogen, but at the end of 5 weeks this condition was reversed. It will be noted also that at the end of the fifth week three corn plants absorbed practically all the nitrogen present in 400 cc. of culture solution in less than 48 hours.

In order to determine what would be the relative rates of absorption of the two forms of nitrogen when present considerably in excess of the amount which the plants could absorb in 48 hours, solutions were prepared containing double and quadruple the amounts of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$ present in the original solution. These solutions contained approximately 160.32 mgm. and 320.0 mgm. total nitrogen per liter, respectively, the two forms of nitrogen being present in approximately equal proportions in each case. Corn plants were grown during a period of 5 weeks and the cultures were then transferred to these, as well as to the original solutions, for an experimental period of 12 hours. The average results of the analyses are presented in table 4.

TABLE 4

Ammonium and Nitrate Nitrogen Removed by Three Maize Plants in 12 Hours from 400 cc. Modified Tottingham Solution $T_3R_1C_1$ Containing 39.2 mgm. and 40.2 mg. per Liter, Respectively, and from Solutions Containing Double and Quadruple This Amount of Ammonium and Nitrate Nitrogen (Average of Two Cultures)—Plants 5 Weeks Old

NITROGEN IN SOLUTION AS		NITROGEN AS NH_4 REMOVED PER LITER	NITROGEN AS NO_3 REMOVED PER LITER
NH_4 per liter	NO_3 per liter		
mgm.	*mgm.*	*mgm.*	*mgm.*
39.2	40.2	19.8	35.5
78.4	80.4	20.8	65.3
156.8	160.8	21.2	72.6

It will be observed that absorption of ammonium nitrogen does not materially increase with increase in concentration of the ammonium salt in solution. On the other hand, increase of nitrate nitrogen does increase markedly as the nitrate content of the medium increases. This has also been suggested in connection with the preceding series. It thus appears that the absolute absorption from solution of nitrogen in the ammonium form takes place at a somewhat uniform rate, which is not determined by the age, vigor, or rate of growth of the plants nor by the concentration of this form of nitrogen in the medium. This means, of course, that the relative absorption rate of ammonium nitrogen per unit area of absorbing surface decreases as the total absorbing surface increases with the age of the plant. It appears further that the factors which affect the absorption rates of ammonium nitrogen do not apply with respect to the rates of absorption of nitrate nitrogen, which are determined, to a certain degree at least, by the age, vigor, and growth rates of the plant and by the concentration of nitrates in the medium. It is certain, however, that the total complex of factors governing the removal of ions containing nitrogen from growth media by plants is as yet quite obscure.

References

(1) Allison, R. V., and Shive, J. W. 1923 Studies on the relation of aeration and continuous renewal of nutrient solution to the growth of soybeans in artificial culture. *Amer. Jour. Bot.* 10:554-566.

(2) American Public Health Association 1923 Standard Methods of Water Analysis, ed. 5. New York.

(3) Hutchinson, H. B., and Miller, N. H. J. 1909 Direct assimilation of ammonium salts by plants. *Jour. Agr. Sci.* 3:179-194.

(4) Jones, L. H., and Shive, J. W. 1921 Effect of ammonium sulfate upon plants in nutrient solutions supplied with ferric phosphate and ferrous sulfate as sources of iron. *Jour. Agr. Res.* 21:701-728.

(5) Jones, L. H., and Shive, J. W. 1923 Influence of ammonium sulfate on plant growth in nutrient solutions and its effect on hydrogen-ion concentrations and iron availability. *Ann. Bot.* 37:355-377.

(6) Prianishnikov, D. N. 1924 On the relation of plants to ammonium carbonate. *Jour. Landw. Wiss.* 1:179-190.

(7) Prince, A. L., Jones, L. H., and Shive, J. W. 1923 Notes on differential ion absorption by plants in relation to reaction change in nutrient solutions. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1922:378-383.

(8) Tottingham, W. E. 1914 A quantitative chemical and physiological study of nutrient solutions for plant cultures. *Physiol. Res.* 1:133-245.

THE EFFECT OF DIFFERENT WATER LEVELS ON THE GROWTH OF CRANBERRIES

B. F. DRIGGERS

Introduction

The management of water on a cranberry bog is one of the most important problems with which cranberry growers have to deal. Where sufficient storage water is available, the practices involved in the handling of large amounts of water, such as flowing for insect control and frost protection, have all been fairly well worked out and understood. On the other hand, considerable variation occurs in practices dealing with irrigation and drainage, even on bogs having similar types of soil.

No data have thus far appeared which tend to show the effect on the growth of the cranberry plant of holding the water level at various depths throughout the growing season. Beckwith (1), basing his opinion on general bog practice, states that "newly planted bogs must be drained to a point at least one foot below the surface of the bog in order to provide room for root development and to keep the surface dry enough to hinder weed seed germination." Franklin (6), writing from the standpoint of bog management in Massachusetts, sums up our knowledge of water requirements in a cranberry soil during the growing season. He says:

> Practice varies in cranberry bog irrigation, and it is not certain what the best usage is. Occasional partial flooding for a few hours at night followed by complete withdrawal of the water is better than holding the ditches full a long time during the growing season. Most bogs probably are kept too wet rather than too dry. Some do, however, sometimes suffer from drought. If the sand is moist within half an inch of the surface, the vines have all the water they need, even though the surface itself is quite dry and the water table is low.

It is a well known fact that the roots of growing plants require oxygen for proper development; some plants require more than others. A comprehensive summary of the extensive literature on the subject has been made by Clements (3).

The oxygen content of water in a saturated soil under ordinary conditions is insufficient for the needs of most agricultural plants. Coville (4) has found that the swamp blueberry, a member of the heath family to which the cranberry also belongs, requires abundant aeration of the root zone during the growing season. Under field conditions in a sandy soil the blueberry grows well when the water table is kept two to three feet below the surface of the soil. The blueberry is a fast growing, deciduous plant, and where the soil becomes saturated for an extended period of time, the foliage of the plant takes on a reddish cast and growth is slow.

Although closely related to the blueberry, the cranberry plant differs from the former quite markedly in several respects. The cranberry plant is a low growing evergreen with a poorly developed root system and with pronounced xerophytic foliar adaptations. Being a slow grower and having tough, leatherly leaves, the cranberry plant would probably not respond to changes in the moisture content of the soil so quickly as a fast growing deciduous plant like the blueberry. However, where the moisture content of the soil is above or below the optimum for this plant, one would expect to note a difference in growth after one or two seasons.

Procedure and Description of the Plots

In the belief that cranberry vines suffer more often from too much moisture in the soil than from too little, a type of soil was selected for the experiment where water levels are more apt to be found high than low. A typical mud bottom bog was selected that had sufficient storage water to maintain the various water levels throughout the growing season.

The history of the bog is as follows: the bog site originally supported a dense mass of cedars, at the base of which grew a carpet of sphagnum moss. The cedar was first cleaned off and the bog planted to cranberries some fifty or sixty years ago. Because of improper care, the original bog became run down and other bog plants, such as blueberry, cedar, maples, and various ferns, began to establish themselves. About twelve years ago the bog was drowned for two years, leveled, reditched, and to all purposes made into a new bog. The new bog was planted with cranberry plants of the Howe variety commonly grown in New Jersey and one that has been found to do well on muck soil. The layer of peat on this bog is made up almost entirely of organic matter. The first six to ten inches is made up of muck-plant remains. Below this layer of well disintegrated organic matter is a layer of roots, stumps, and logs that have been fairly well preserved by being submerged. Under this layer of stumps and logs is a layer of coarse sand and gravel, and below that a layer of "hard pan." At the time the experiment was started in 1922, the vines were nine to ten yeras old and were just coming into good bearing.

Drainage of the bog was secured by means of a central ditch that divided the bog approximately into halves. Laterals at 10-rod intervals extended from the shore to the central ditch. One of the "lands"[1] near the middle of the bog was divided into plots 1 rod square, with 1-rod intervals between the plots. An examination of figure 1 will give a clear picture of the layout of the plots. It will be seen from the figure that there are 5 rows of plots, each row containing 5 plots. It was planned to hold the water at various levels in the lateral ditches at the outer limits of the rows. Suitable stops were placed in the ditches to hold the water at the required levels. Arrows show the direction of flow of the irrigation water, and the figures between the "stops" in the margins representing the ditches show the level of the water below the surface of the bog. It was planned to hold the water at the surface or only 2 to 3

---

[1] A "land" is the area between two lateral ditches.

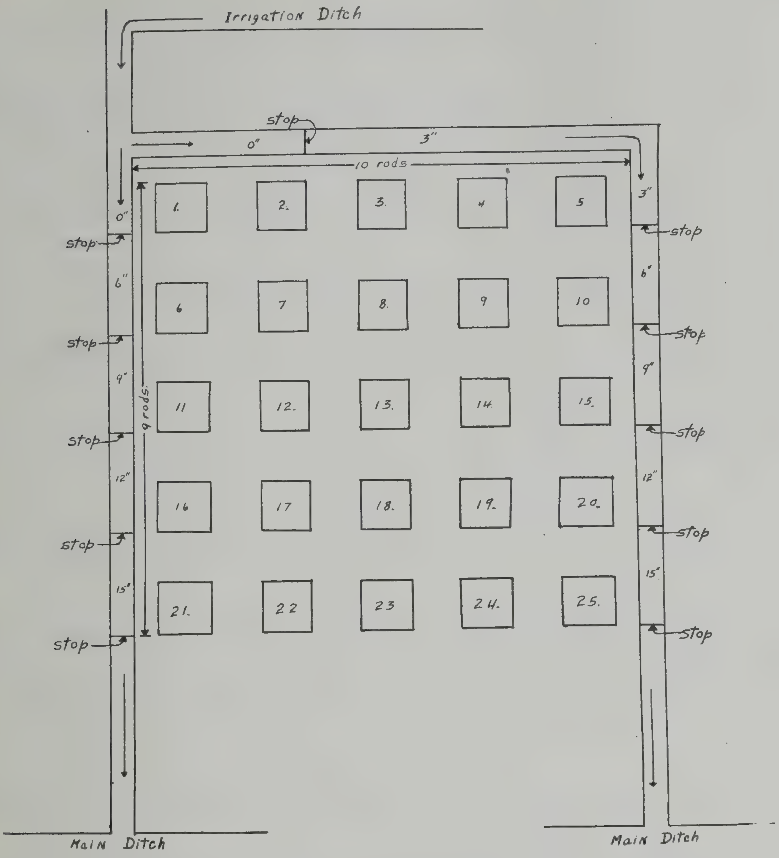


FIG. 1. PLAN OF EXPERIMENTAL PLOTS

inches below the surface, in the first row of plots, 6 inches below the surface in the second row, 9 inches in the third row, 12 inches in the fourth row, and 15 inches in the fifth row.

When the water levels were first adjusted, it was noticed that the water levels of the plots farthest away from the ditches would fluctuate more than the water levels of the plots nearest the ditches. Also there was a sloping off of the water table from the first row of plots toward the last row of plots, because of slow seepage from a higher to a lower water level. In order to record the actual water levels throughout the season, wells were dug at the four corners of each plot below the probable water level. Measurements of the water level in these wells were made every second or third day throughout the growing season. In this way the average water level throughout the growing season was secured for each plot.

The different water levels were not adjusted in time to affect the growth for the season of 1923. The water levels were adjusted and held from August 1 to September 1, 1923. Lack of water in the reservoir necessitated the lowering of all the water levels at that time. In 1924 the water levels were maintained from the middle of May until September 26, when the crop was harvested. During 1925 the water levels were maintained from June 9 to September 7.

TABLE 1

Vegetative Growth, Yield, and Percentage of Rot for Three Seasons

Plot number	1923					1924					1925				
	Depth of water	Average length uprights	Average number uprights	Yield	Rot	Depth of Water	Average length uprights	Average number uprights	Yield	Rot	Depth of Water	Average length uprights	Average number uprights	Yield	Rot
	inches	*inches*		*pounds*	*percent*	*inches*	*inches*		*pounds*	*per cent*	*inches*	*inches*		*pounds*	*per cent*
1	0.53	3.30	422	29.5	60.0	0.65	2.64	316	59.3	35.5	0.91	2.32	363	9.3	5.0
2	0.92	3.37	376	22.5	11.5	1.89	2.40	310	63.5	23.0	2.71	2.19	376	18.0	4.5
3	3.17	3.11	361	32.5	32.0	2.36	2.60	314	53.5	25.0	3.50	2.20	371	22.8	3.0
4	3.38	3.04	348	35.0	28.0	3.24	2.64	312	56.8	16.0	4.10	2.32	397	19.3	2.0
5	3.35	3.35	377	32.8	22.0	3.50	2.74	366	44.0	22.0	4.05	2.33	402	17.0	3.0
6	5.95	3.04	364	21.3	30.0	4.97	3.01	359	51.0	27.0	5.37	2.60	443	23.8	5.5
7	6.45	2.73	369	21.5	31.0	4.45	2.96	343	62.0	23.0	5.90	2.51	431	22.5	2.0
8	6.50	2.84	409	26.0	15.0	4.60	3.13	373	67.0	13.0	6.10	2.50	452	18.8	3.0
9	6.83	2.85	372	30.5	16.0	4.77	2.81	350	62.0	19.0	6.14	2.60	435	20.5	2.5
10	9.10	2.82	320	33.5	27.0	5.10	2.71	382	47.0	15.5	6.30	2.56	434	22.0	2.5
11	9.50	2.73	355	19.3	27.0	8.60	3.09	352	71.0	40.0	9.28	2.53	432	26.5	6.0
12	9.80	2.99	380	7.5	32.0	6.60	3.07	396	76.3	30.0	7.91	2.75	486	20.3	5.5
13	11.15	3.13	355	13.8	14.0	6.50	3.30	405	72.0	13.0	8.50	2.89	487	15.5	2.5
14	10.17	2.79	362	22.8	4.0	6.88	3.05	352	68.3	11.0	9.00	2.87	483	16.5	2.0
15	12.50	3.07	366	22.3	4.0	7.75	3.01	391	56.5	7.0	9.34	2.81	469	17.3	4.0
16	12.80	2.70	360	15.3	11.0	10.50	3.32	397	65.0	16.0	11.50	2.98	486	25.0	3.5
17	13.28	2.70	303	19.5	9.0	9.70	3.15	403	75.3	14.5	11.53	2.93	484	28.0	3.0
18	13.90	2.74	346	18.0	16.0	9.50	3.14	398	72.3	9.5	11.95	3.15	448	24.0	4.5
19	14.95	2.80	350	22.5	1.0	9.30	3.03	376	83.0	3.0	11.70	2.80	478	24.3	1.0
20	16.66	2.99	346	24.3	5.0	11.03	3.19	396	62.7	6.0	12.29	2.75	482	27.0	2.0
21	....	2.95	365	13.0	18.0	12.50	3.19	390	66.3	10.0	13.32	3.08	479	23.0	3.5
22	....	2.53	350	19.0	12.0	12.40	3.35	384	76.0	7.0	13.94	3.06	510	26.0	3.5
23	....	2.57	346	20.0	5.0	12.80	3.28	375	70.0	6.5	14.35	3.49	459	22.0	2.5
24	....	2.53	317	24.5	5.0	12.40	3.12	343	83.5	9.0	13.85	3.13	390	30.8	1.5
25	....	2.67	314	27.2	5.0	14.40	3.12	355	61.5	3.0	15.84	3.28	423	20.0	2.0

Measurements of Vegetative Growth and Crop Production

The vegetative growth of the plants on the several plots was recorded by measuring the length of the uprights and by counting the number of uprights to a square foot. Seventy-five uprights were measured in opposite corners of each plot and the average length of the 150 uprights was taken as the average length for the whole plot. The number of tips to a square foot in opposite corners of each plot was counted and the average of the two taken as the average for the plot. The yield of berries from each plot was recorded in pounds. The percentage of rot found on each plot was determined by mixing the berries thoroughly and counting the number of infected berries in a lot of 400 from each plot.

Table 1 is a compilation of all the data for each plot for the growing seasons 1923, 1924, and 1925. These data do not show very clearly the effect of the different water levels on the growth and yield of the cranberry vines, because of the variation encountered from plot to plot. In order to show more clearly the effects on the vines of the different water levels, the data in table 1 were condensed by combining and averaging the data obtained from the plots having water levels the same or nearly the same. All of the 25 plots were divided into 5 arbitrary groups, depending on the depth of the water level. Thus: group 1 is made up of plots 1, 2 and 3, and represents the water levels between 0 and 3 inches; group 2 is made up of plots 4 to 10 inclusive and represents water levels between 3 and 6 inches; group 3 is made up of plots 11 to 15 inclusive and represents water levels between 6 and 9 inches; group 4 is made up of plots 16 to 20 inclusive and represents water levels between 9 and 12 inches; group 5 is made up of plots 21 to 25 inclusive and represents water levels between 12 and 15 inches.

It should be borne in mind that the water levels for 1923 (table 2) were held only 1 month during the latter part of the growing season. The water levels probably affected only the amount of rot. The remainder of the data in table 2 show the condition of the plots at the time the experiment was started. Tables 3 and 4 show the effects of the water levels for the seasons 1924 and 1925.

Discussion of Results

The Effect of Different Water Levels on the Vegetative Growth

An examination of that part of the data dealing with vegetative growth in table 2 shows that the plots where the water levels were held nearest the surface during the following seasons (1924-25) had a heavier vegetative growth than the plots where the water levels were held low. These data serve only to show the condition of the plots at the time the experiment was begun, since the vegetative growth, and to a large extent the crop of this season (1923) had already been determined before the water levels had been adjusted; so that the adjusted water levels at this period (August 1) could affect only the development of disease attacking the crop. That the adjustment of the water levels

Table 2

Vegetative Growth, Yield, and Percentage of Rot for 1923

	Group 1	Group 2	Group 3	Group 4	Group 5
Depth of water level..........*inches*	0–3	3–6	6–9	9–12	12–15
Average length of uprights....*inches*	3.29	2.95	2.94	2.78	2.65
Average number uprights per square foot	387	366	363	341	339
Yield ....*pounds*	28.20	28.65	17.12	0.92	20.74
Rot ....*per cent*	34.5	24.14	16.2	8.4	9.0

at this period had a decided influence upon the prevalence and development of the disease is clearly shown by the data of table 2, but this will be considered in a later section.

An examination of tables 3 and 4 shows that the vegetative growth for the seasons of 1924 and 1925, as measured by the average length and number of uprights, is the reverse of that found in table 2 for the season of 1923. During these two seasons the vegetative growth was found to be lowest where the water level was highest, increasing with each lowering of the water level until a depth of 12 inches was reached. After this no further increase in vegetative growth was obtained with further lowering of the water level. Best average growth was obtained on the plots where the water levels were held about 12 inches below the surface of the bog soil.

TABLE 3

Vegetative Growth, Yield, and Percentage of Rot for 1924

	Group 1	Group 2	Group 3	Group 4	Group 5
Depth of water level..........*inches*	0–3	3–6	6–9	9–12	12–15
Average length of uprights....*inches*	2.54	2.85	3.10	3.146	3.012
Average number uprights per square foot	313	355.1	379.3	390.1	369.4
Yield ....*pounds*	58.7	55.7	68.82	71.66	71.46
Rot ....*per cent*	27.8	19.4	20.2	9.8	7.1

TABLE 4

Vegetative Growth, Yield, and Percentage of Rot for 1925

	Group 1	Group 2	Group 3	Group 4	Group 5
Depth of water level..........*inches*	0–3	3–6	6–9	9–12	12–15
Average length of uprights....*inches*	2.37	2.49	2.77	2.90	3.16
Average number uprights per square foot	370	427.7	471.4	475.6	452.2
Yield ....*pounds*	16.7	20.5	19.2	25.6	24.3
Rot ....*per cent*	4.16	2.93	4.16	2.8	2.6

Throughout the growing season of 1924 the foliage on the plots where the water level was highest showed an unhealthy tone. Instead of the dark green that is characteristic of a healthy cranberry plant, the foliage had a slightly yellowish cast, particularly in the first group of plots. During the season of 1925 the yellowish color of the foliage was even more marked than it was during the season of 1924. Throughout the season, the foliage on the plots with highest water levels had a yellowish-red cast that could be noted from a distance.

Effect of Different Water Levels on the Yield

The difference in yield between plots from high water levels to low water levels is even more pronounced than is the difference in the vegtative growth. The data of tables 3 and 4 show that the higher water levels cause a marked decrease in yield, in comparison with the yield from the plots with lower water levels. This clearly indicates that a water level held at 6 inches or less below the soil surface of the bog in question during the season of active development exerted a decidedly adverse influence upon both vegetative growth and yield of the cranberry. This is emphasized by the fact that the vegetative growth of the preceding year was most vigorous and the crop largest on these very plots which showed relatively the lowest plant vigor and smallest crop of the seasons 1924 and 1925 under the adverse influence of high water levels. It is generally true that the larger the number of uprights per square foot, the smaller the percentage of total uprights bearing fruit. As the number of uprights per square foot decreases, the percentage of the total uprights bearing fruit increases. This variation tends to stabilize the yield. Nevertheless, the yields, with some exceptions, generally follow the trend of vegetative growth as here measured by the average length and number of uprights. The explanation of the superiority of the yields of all the plots in 1924 over those of the corresponding plots in 1923 lies in the fact that the vines had not come into full bearing in the season of 1923. It will be observed also that the yields from the several plots were considerably lower in 1925 than were the corresponding yields in 1924. This falling off in the yields for 1925 was caused partly by a heavy frost that injured the vines in the late spring of 1925 and partly by the adverse weather conditions obtaining at the time of blooming.

Effect of Different Water Levels on the Percentage of Rot

The most noticeable effect of holding the water at the various levels during 1923 was in the amount of rot. Although the water was held at the various levels only during the month of August, 1923, the increase of rot where the water level was highest over that where it was lowest was very pronounced. This increase where the water levels were highest was to have been expected when it is considered that the fruit on the vines is subject to infection up to the time of harvesting, and also in storage, provided the conditions for the development of the fungus are favorable. For vigorous development, the fungi causing cranberry diseases (principally *Guiguardia vaccinii* Shear, and *Acanthorynchus vaccinii* Shear) require moisture and a rather high temperature. Summer temperatures on cranberry bogs are sufficiently high for these diseases to infect the berries, provided there is sufficient moisture. The presence of excess moisture on the plots where the water levels were highest explains the high percentage of rot.

The percentage of rot for 1924 follows, in general, the percentage of rot for 1923. Here again was found the highest percentage of rot where the water levels were highest and the lowest percentage where the water levels were lowest. The percentage of rot for 1925 was not large enough on the plots as a whole to show any distinct differences between the high and low water levels, yet here again the highest and lowest percentages of rot occurred on the plots having, respectively, the highest and the lowest water levels. The unusually low percentage of rot on all the plots is probably accounted for by the weather conditions prevailing during the growing season of 1925. At the beginning of the season's growth, the bog was frosted rather severely. This frost injury cut down the probable crop as much as 25 or 50 per cent. During the month of June another inroad was made on the crop by a week of hot, dry weather, followed by several days of rain when the vines were coming into bloom. The hot, dry weather caused a number of the immature blossoms to wither and dry up, and the wet weather following the dry weather was favorable for the development of the fungus *Acanthorynchus vaccinii* Shear, which causes the blasting of cranberry blossoms; consequently, the number of blossoms failing to set fruit was increased by this disease. Those berries which survived the unfavorable weather conditions of early summer experienced favorable weather for the remainder of the growing season and were, therefore, almost free from infection by fungous diseases. It is reasonable to suppose, also, that, other things being equal, vines having a light crop can mature a larger percentage of sound berries than vines having a heavy crop.

Another factor that probably contributed to the low percentage of rot in 1925 was the time of harvesting. The crop was harvested that year two weeks before the berries were mature. It was necessary to harvest the crop early, in order to flood the bog for the control of the cranberry girdler. Had the crop remained on the vines two weeks longer there would undoubtedly have been additional infection.

References

(1) Beckwith, C. S. 1922 Cranberry growing in New Jersey. N. J. Agr. Exp. Sta. Cir. 144.

(2) Bergman, H. F. 1920 The relation of aeration to the growth and activity of roots and its influence on the ecesis of plants in swamps. *Ann. Bot.* 34:13.

(3) Clements, F. E. 1921 Aeration and Air Content. The Role of Oxygen in Root Activity. Carnegie Inst. Wash. Pub. 315.

(4) Coville, F. V. 1910 Experiments in blueberry culture. U. S. Dept. Agr. Bur. Plant Indus. Bul. 193.

(5) Dachnowski, A. 1912 The Nature of the absorption and tolerance of plants in bogs. *Bot. Gaz.* 54:503.

(6) Franklin, H. J. 1923 Cranberry growing in Massachusetts. Mass. Agr. Col. Ext. Leaflet 72.

Report of the Department of Poultry Husbandry

W. H. Allen[1]

PUBLICATIONS

One of the many ways in which the department of poultry husbandry keeps in touch with the poultrymen in this state is through its publications. During the year twelve numbers of the Hints to Poultrymen series have been published. Approximately 9,000 copies have been mailed each month to people of the State desiring them. Poultrymen of other states and foreign countries are asking for these publications and an effort has been made to supply this demand. In the Hints to Poultrymen series, investigations in progress and those completed at this Station and at other Experiment Stations are reported in popular style as a guide to practical poultrymen.

A list of Hints published during the past year, and their authors is given on page 47 of this report.

During the year approximately 52 popular articles were written by members of the staff for the newspapers of New Jersey. Monthly articles were also written for New Jersey Agriculture. It is estimated conservatively that 200,000 people are reached monthly by the total publicity material emanating from the department.

GENERAL AND PERSONAL SERVICE

Because poultry keeping plays such an important economic part on most of the farms in New Jersey, and because of the fine reputation that this department has always had among the farmers of the state, it is only natural that the department is called upon to do a great deal of personal service, such as visiting farms, giving addresses at public meetings, and answering many letters calling for poultry information.

The following table shows approximately the amount of work done along this line by the department:

Number of letters written	8,133
Number of letters to contestants	1,200
Number of farm visits	160
Number of meetings addressed	60
Attendance at meetings	4,500

---

[1] Acting Poultry Husbandman in the absence of Willard C. Thompson, Poultry Husbandman.

The 1,200 letters to contestants listed in the above report are special letters which have been sent out from time to time whenever the supervisor had information which he thought wise to bring to the attention of the contestants. Since October 1, a count has been kept of the number of mimeographed articles prepared—147 stencils have been written, and 52,300 copies issued.

NEW JERSEY EGG LAYING CONTESTS

Vineland International Egg Laying Contest

This report takes up the third year of the last of the three-year contest plan at Vineland. The report is for the period from November 1, 1924, through October 31, 1925. The total production for the year was 221,959 eggs, which is equivalent to 128.2 eggs for each bird. The percentage production for the year was 35.11. Table 1 shows the percentage production, and the number of eggs produced by each bird for each month during the year.

TABLE 1

Egg Production by Months

Month	Per cent	Eggs per bird
November	4.0	1.20
December	26.1	8.01
January	40.0	12.40
February	45.8	12.30
March	49.1	15.20
April	53.1	15.90
May	52.1	16.10
June	42.6	14.10
July	39.6	13.50
August	40.2	12.40
September	21.2	6.30
October	...	...

The best production for any one pen was made by the C. C. Poultry Farm, New Brunswick, N. J., a Rhode Island Red pen, which made a production of 3,593 eggs. This is also the best record ever made at the contest by a Rhode Island Red pen.

The leading pens in each variety at the Vineland Contest are as follows:

TABLE 2

Leading Pens in Each Variety

Variety	Pen No.	Owner	Production
B. P. Rock	4	W. H. B. Kent, Cazenovia, N. Y	3,560
W. Wyandotte	94	D. O. Witmer, Joplin, Mo.	2,923
S. C. W. Leg.	35	A. L. Causse, Jr., Toms River, N. J.	3,115
R. I. Reds	13	C. C. Poultry Farm, New Brunswick, N. J.	3,593

The ten highest pens at the Vineland Contest are given below:

TABLE 3

Ten Highest Pens in the Contest

Variety	Pen No.	Owner	Production
R. I. Red	13	C. C. Poultry Farm, New Brunswick, N. J.	3,593
B. P. Rock	4	W. H. B. Kent, Cazenovia, N. Y.	3,560
B. P. Rock	7	Norfolk Specialty Farms, St. Williams, Ont.	3.297
S. C. W. Leg.	35	A. L. Causse, Jr., Toms River, N. J.	3,115
S. C. W. Leg.	48	E. H. Wene, Vineland, N J	3,108
B. P. Rock	3	A. C. Jones, Georgetown Del.	3,030
R. I. Red	24	A. J. Tipping, Englewood, N. J.	3,017
S. C. W. Leg.	57	Chas. E. Grove, Milford, Del.	2,926
W. Wyandotte	94	D. O. Witmer, Poplin, Mo.	2,923
R. I. Red	23	H. G. Taylor, Jr., Riverton, N. J.	2,900

The eleven highest individuals making a record running from 252 up to 287 eggs, are given in the following table:

TABLE 4

Eleven Highest Individuals

Variety	Pen No.	Owner	Production
W. Wyandotte	14-12	August Weiss, Upper Saddle River, N. J.	287
R. I. Red	13- 5	C. C. Poultry Farm, New Brunswick, N. J.	262
S. C. Leg.	93- 6	James Whetsel, Vineland, N. J.	261
W. Wyandotte	94-11	D. O. Witmer, Joplin, Mo.	260
R. I. Red	13- 3	C. C. Poultry Farm, New Brunswick, N. J.	258
W. Wyandotte	94-15	D. O. Witmer, Joplin, Mo.	256
B. P. Rock	4-13	W. H. B. Kent, Casenovia, N. Y.	256
W. Wyandotte	94- 9	D. O. Witmer, Joplin, Mo.	254
B. P. Rock	4- 9	W. H. B. Kent, Cazenovia, N. Y.	252
W. Wyandotte	14-16	August Weiss, Upper Saddle River, N. J.	252
R. I. Red	20- 2	Maple Farms, Crosswicks, N. J.	252

Table 5 gives the feed report of the Vineland Contest by classes for eleven months.

TABLE 5

Feed Summary

	B. P. Rock	W. P. Rock	W. Wyan.	R. I. Red	S. C. W. Leg.	J. B. Giants	Brown Leg.
Number of birds	120	35	36	195	1296	33	17
Pounds grain consumed	47.34	44.03	41.06	45.19	37.79	47.88	33.26
Pounds mash consumed	34.58	32.4	30.02	32.74	27.92	36.05	21.86
Feed cost per bird	2.417	2.265	2.074	2.279	1.932	2.469	1.538
Number eggs per bird	145.1	130.9	145.3	144.5	127.7	114.2	60.58
Value of eggs per bird	6.675	6.022	6.685	6.65	5.74	5.256	2.787
Return above feed cost	4.258	3.757	4.611	4.371	3.808	2.787	1.249

On November 1, 1925, the contest at Vineland was put on a one-year plan, which means that the birds are kept one year, trapped through for the twelve months, and then sent home to the owners.

The contest at that time started its tenth year. It was only natural, therefore, that the houses, fences, and general equipment of the plant should have deteriorated considerably in that period. One of the big problems facing the new management was not only to pay up the indebtedness of the contest, but also to put the plant in a workable condition. A joint committee of the Vineland Poultry Association and the Vineland Chamber of Commerce, consented to solicit funds for this purpose. Through their efforts sufficient funds were obtained to make the needed repairs of the buildings and to put in concrete sills and floor.

A special appropriation of $6,000 was obtained from the Legislature, $3,000 of which is being used to construct new fences, put the yards in permanent alfalfa sod, paint the buildings, and make other necessary repairs.

Since November 1, the past indebtedness of the contest has been practically wiped out, largely because of the exceptionally fine production being obtained. For the first six months of the present contest year 28,000 more eggs were obtained from the 1,000 birds than were obtained for the same period last year. Very likely the present contest will make a record for a production higher than was ever made there before, and better than has ever been made at any contest in the East.

Bergen County Contest

The production for the year at the Bergen County Egg Laying Contest, which completed its second year as a one-year contest on

TABLE 6

Egg Production by Months

Month	Per cent	Eggs per bird
November	15.1	6.3
December	28.7	9.5
January	29.8	9.0
February	37.0	10.3
March	56.5	17.5
April	62.9	18.9
May	55.5	17.2
June	43.8	14.4
July	49.7	15.4
August	44.7	13.8
September	28.9	8.9
October	14.1	4.4

October 31, 1925, was 288,443 eggs, which is equivalent to 144.4 eggs per bird for the entire year. The percentage production for the year was 39.5 per cent. Table 6 gives the percentage production and the number of eggs produced by each bird for each month during the year.

TABLE 7

Leading Pens in Each Variety

Variety	Pen No.	Owner	Production
B. P. Rock	3	A. C. Jones, Georgetown, Del.	3,298
W. P. Rock	11	W. C. Matthews, Wilmington, Del.	3,137
W. Wyandotte	17	Horton Poultry Farm, Columbus, O.	3,335
R. I. Red	20	Beacon Poultry Farm, Linden, N. J.	3,040
S. C. W. Leg.	31	Laurel Hill Poultry Farm, Pearl River, N. Y.	4,092
Anconas	22	W. H. Stetson, Westwood, N. J.	2,981
Br. Leg.	97	Hamilton's Leghorn Farm, Glenford, O.	2,551

TABLE 8

Ten Highest Pens in the Contest

Variety	Pen No.	Owner	Production
S. C. W. Leg.	31	Laurel Hill Poultry Farm, Pearl River, N. Y.	4,092
S. C. W. Leg.	32	Henry J. Ebel, North Warren, Pa.	3,983
S. C. W. Leg.	87	Henry Rapp, Jr., Farmingdale, N. J.	3,743
S. C. W. Leg.	48	Hollywood Poultry Farm, Woodinville, Wash.	3,714
S. C. W. Leg.	80	Willgerodt Bros., Red Bank, N. J.	3,648
S. C. W. Leg.	29	Wene Farms, Pittstown, N. J.	3,630
S. C. L. Leg.	53	Dr. L. E. Heasley, Grand Rapids, Mich.	3,625
S. C. W. Leg.	72	Novins Poultry Farm, Toms River, N. J.	3,561
S. C. W. Leg.	41	Arnold Poultry Farm, Metuchen, N. J.	3,523
S. C. W. Leg.	39	Geo. B. Ferris, Grand Rapids, Mich.	3,510

TABLE 9

Thirteen Highest Individuals

Variety	Pen No.	Owner	Production
S. C. W. Leg.	59- 7	D. A. Williams, Kennedy, N. Y.	275
S. C. W. Leg.	78-17	The Kerr Chickeries, Frenchtown, N. J.	272
S. C. W. Leg.	83- 4	Marquis Poultry Farm, Toms River, N. J.	270
S. C. W. Leg.	39- 4	Geo. B. Ferris, Grand Rapids, Mich.	268
S. C. W. Leg.	68- 9	E-Van-So Farm, Elizabeth, Pa., R. D. No. 3	262
S. C. W. Leg.	66- 5	Evergreen Farm, Ridgewood, N. J.	257
S. C. W. Leg.	32-18	Henry J. Ebel, North Warren, Pa.	255
S. C. W. Leg.	80-10	Willgerodt Bros., Red Bank, N. J.	255
S. C. W. Leg.	54- 6	Norman C. Jones, Georgetown, Del.	254
W. P. Rock	11- 8	W. C. Matthews, Wilmington, Del.	252
S. C. W. Leg.	54- 8	Norman C. Jones, Georgetown, Del.	252
S. C. W. Leg.	72- 5	Novins Poultry Farm, Toms River, N. J.	252
S. C. W. Leg.	72-19	Novins Poultry Farm, Toms River, N. J.	252

TABLE 10

Feed Summary

	B. P. Rock	W. P. Rock	W. Wyan.	R. I. Red	S. C. W. Leg.	Buttercup	Ancona	Br. Leg.	Houdans
No. of birds	220	40	100	60	1480	60	40	20	20
Lbs. grain consumed	41.09	40.8	41.36	41.0	38.54	40.0	39.22	39.71	41.66
Lbs. mash consumed	40.58	43.42	34.1	41.9	35.54	23.94	30.02	32.2	37.89
Feed cost per bird.	2.336	2.362	2.092	2.369	2.112	1.915	2.153	2.031	2.438
No. eggs per bird.	133.7	130.3	124.4	142.3	147.7	72.36	131.2	127.5	96.9
Val. eggs per bird.	6.151	5.996	5.724	6.548	6.798	3.328	6.035	5.867	4.457
Ret'n abv. feed cost.	3.815	3.634	3.632	4.179	4.686	1,413	3.882	3.836	2.019

Of the $6,000 appropriated by the Legislature for the repair of the contests, $3,000 is being used at the Bergen County Egg Laying Contest in the repair of fences and buildings. New fences are being constructed throughout the plant, new mash hoppers installed, as well as new trap nests and roosts. After this work is completed, two coats of paint will be given to the entire plant, which will make this contest more attractive and efficient from a production and health standpoint.

NEW JERSEY POULTRY EXHIBITIONS

One of the duties of this department is the administration of the Poultry Exhibition Fund, which made available $6,500 last year for aiding competition among poultry keepers of the state and for staging a suitable exhibition of purebred poultry. This project has been running for six years.

In administering this fund, the aim has been to apportion the money for payment on premiums to one show in each county for each year. This show is usually run by the local poultry association in the county, and when more than one association is asking for the money it is awarded to the one having the largest entry list during the preceding year. It has always been the plan to award the exhibition money to local shows run under the auspices of local poultry associations rather than to poultry shows held in connection with a fair. However, the poultry show held in connection with the State

Fair at Trenton has been allowed to participate in the fund because this show represents the state-wide exhibition of fowls in the autumn.

The regular winter State Show was held at Trenton under the auspices of the Mercer County Poultry Association and in connection with Farmers' Week at the State Armory, Trenton, N. J., January 11 to 15, 1926. Local shows in the following counties participated in the fund this year:

Trenton Fair Association Poultry Show.
Flemington Fair Association Poultry Show.
Atlantic County Fair Association Poultry Show
Vineland Poultry Association.
Essex County Poultry Association.
Sussex County Fair Association Poultry Show.
Morristown Poultry and Pet Stock Association.
Middlesex County Poultry Association.
Gloucester County Poultry Association.
Mercer County Poultry Association.
Hackettstown Poultry Association.
Riverside Poultry Association.

Except for a small amount used for administration and exhibit material, all the funds were devoted to premium money for which the fund was originally provided.

RESEARCH PROGRAM

The Experimental Poultry Plant

During the past year considerable work in remodeling the poultry plant at the Station has been carried on so as to make this plant more efficient from a research standpoint. The brooder house has been remodeled so as to carry on necessary studies relative to brooding chicks in confinement for the control of worms and coccidiosis. A 10-foot concrete slab has been laid the whole length in front of the brooder house, which makes it possible to control the runs. For the study of that phase of young stock infection, half the brooder house has been screened in to control insects and flies. Most of the colony houses out on the range have been repaired, and necessary alterations have been made to make them more practical for the important studies carried on at this station.

At the Vineland Training School, where the pathologist, Dr. Black, of this station, has his office to carry on poultry disease research in South Jersey, there has been constructed an animal house at a cost of approximately $500, which will make possible the study of intermediate hosts for tapeworms.

Nutrition Experiments

FOREST H. CLICKNER

A Study of the Value of Protozyme, a Fungus Enzyme, in the Feeding of Poultry—Project C 1-24

Five pens of chicks, about 200 to a pen, were started on March 1, 1925, in an experiment to determine the effect of feeding this enzyme on growth. One pen received protozyme at the rate of 5 per cent of its mash, by weight, another 3 per cent, a third 2 per cent, a fourth 1 per cent, and the fifth pen received no protozyme. The results of this experiment were reported in the annual report for 1925.[1]

On August 1, 1925, the pullets that were reared from the above lot of chicks were housed in 10 pens of 50 each. They were housed at this time because a number of them started to lay, and as it was desired to have a check on how these birds would do during their pullet year as layers, it was necessary that all conditions be alike and that they be under closer observation. It is interesting to note that the birds in the check pen were the first to lay, even though they were not so heavy as those getting the protozyme. They were followed, however, within three or four days by those getting protozyme.

To determine whether enzymes are needed merely to grow stock and not for egg production after the birds have been grown on it, or whether it is also needed after the birds have been grown on it, the birds were divided so that some grown on protozyme are getting it as layers and some are not. The pens were, therefore, divided as follows:

Pen 1. Grown on 5% protozyme. Getting 5% protozyme as layers
Pen 2. Grown on 3% protozyme. Getting 3% protozyme as lyaers
Pen 3. Grown on 2% protozyme. Getting 2% protozyme as layers
Pen 4. Grown on 1% protozyme. Getting 1% protozyme as layers
Pen 5. Check no protozyme. Getting no protozyme as layers
Pen 6. Grown on 5% protozyme. Getting no protozyme as layers
Pen 7. Grown on 3% protozyme. Getting no protozyme as layers
Pen 8. Grown on 2% protozyme. Getting no protozyme as layers
Pen 9. Grown on 1% protozyme. Getting no protozyme as layers
Pen 10. Check no protozyme. Getting 2% protozyme as layers

The birds were fed the following New Jersey Rations:

Scratch, equal parts of cracked corn and whole wheat; equal parts of wheat bran, wheat middlings, ground oats (fine), corn meal, meat scrap (50%).

---

[1] Report of the Department of Poultry Husbandry, N. J. Agr. Exp. Sta. Ann. Rpt., 1925.

Tables 1 to 10 give the results for 11 months of the first laying year. The cost figures are based on the following prices: scratch $2.50 per 100 pounds, mash $2.98 per 100 pounds, protozyme $25.00 per 100 pounds. The value of the eggs was based on the current monthly top New York prices.

The health in all pens excepting pen 10 was normal. This pen received a severe setback in that it was being continually attacked by bronchitis, which left the pen with a final bird population of but 27 birds. The figures from this pen are, therefore, of little consequence.

TABLE 1

Pen 1—5 Per Cent

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	278	$12.454	178	67.85	3.474
September	575	30.992	178	98.70	3.768
October	459	29.284	186	100.30	3.695
November	198	19.592	180	84.90	3.665
December	199	10.1092	186	95.75	3.900
January	355	15.661	176	115.35	4.176
February	397	14.5302	191	124.30	4.340
March	894	28.2504	217	125.00	4.400
April	978	30.9048	180	157.50	4.340
May	1073	34.8725	155	168.00	4.260
June	943	31.4019	150	147.00	4.080
Totals	6349	$258.082	1977	1275.25	

Feed cost—Grain, $49.425; mash, $52.03.
Profit—$156.62.

TABLE 2

Pen 6—5 Per Cent Check

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	326	$14.604	175	81.55	3.290
September	429	23.1231	180	86.35	3.695
October	365	23.287	186	86.90	3.612
November	140	8.456	164	49.45	3.501
December	166	8.4238	186	78.85	3.800
January	222	9.8124	176	76.40	4.032
February	422	11.7852	191	88.50	4.120
March	716	22.6256	217	121.50	4.130
April	822	25.9752	180	148.00	3.950
May	868	28.21	155	102.00	3.930
June	830	27.6390	148	140.00	3.913
Totals	5306	$203.95	1958	1059.50	

Feed cost—Grain, $48.95; mash, $31.57.
Profit—$123.43.

TABLE 3

Pen 2—3 Per Cent

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	305	$13.604	169	77.70	3.172
September	499	26.8961	177	83.50	3.455
October	619	39.4922	186	114.25	3.440
November	305	18.4220	180	108.15	3.493
December	208	10.5664	186	96.20	3.681
January	442	19.5364	176	101.65	3.912
February	489	17.8974	189	120.55	4.021
March	911	28.7876	217	123.95	4.100
April	924	29.1884	180	154.50	4.000
May	1028	33.4100	155	164.80	4.000
June	906	30.1698	150	144.20	3.773
Totals	6638	$271.036	1965	1299.45	

Feed cost—Grain, $49.125; mash, $47.30.
Profit—$174.60.

TABLE 4

Pen 7—3 Per Cent Check

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	329	$14.7392	163	82.35	3.134
September	495	26.6805	161	74.05	3.149
October	304	19.3952	181	67.60	3.190
November	75	4.5400	160	67.50	3.102
December	164	8.3312	186	79.80	3.611
January	556	24.5752	176	93.40	3.887
February	600	21.9600	181	101.30	3.984
March	791	24.9956	217	121.50	3.970
April	947	29.9252	180	125.00	3.490
May	866	28.1450	155	110.00	3.500
June	683	22.7439	145	120.00	3.672
Totals	5810	$226.02	1915	1042.50	

Feed cost—Grain, $47.875; mash, $31.06.
Profit—$147.07.

TABLE 5

Pen 3—2 Per Cent

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	263	$11.7824	164	64.2	3.029
September	362	19.5118	177	67.8	3.409
October	470	29.9860	186	105.1	3.553
November	224	13.5296	180	84.7	3.462
December	181	9.1948	186	83.9	3.643
January	343	15.1606	176	94.7	3.842
February	333	12.1878	188.6	76.5	4.020
March	719	22.7204	217	123.0	4.060
April	934	29.5144	180	153.0	3.950
May	959	31.1675	155	132.6	3.950
June	710	23.9760	145	142.8	3.597
Totals	5508	$218.73	1954.6	1128.3	

Feed cost—Grain, $48.865; mash, $38.587.
Profit—$131.27.

TABLE 6

Pen 8—2 Per Cent Check

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	288	$12.9024	167	70.6	3.0
September	481	25.9259	172	77.2	3.442
October	278	17.7364	178	64.8	2.997
November	61	3.6844	150	55.9	2.937
December	90	4.5720	186	67.4	3.476
January	367	16.2214	176	79.2	3.828
February	453	16.5798	191	81.9	3.977
March	759	23.9844	215	105.5	3.960
April	844	26.6704	175	126.2	3.310
May	788	25.6100	155	109.8	3.400
June	635	21.1455	145	110.0	3.557
Totals	5040	$195.032	1910	948.5	

Feed cost—Grain, $47.75; mash, $28.265.
Profit—$119.01.

TABLE 7

Pen 4—1 Per Cent

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	211	$9.4528	171	56.70	2.878
September	389	20.967	177	90.40	3.839
October	540	34.452	186	104.20	3.482
November	297	17.9388	180	69.60	3.434
December	181	9.1948	186	71.80	3.479
January	208	9.1936	176	75.10	3.651
February	325	11.8950	189.55	76.85	3.719
March	762	24.0792	217	120.95	3.800
April	882	27.8912	180	122.50	3.750
May	908	29.5100	155	131.30	3.690
June	850	28.3050	150	141.40	3.584
Totals	5553	$222.859	1967.55	1040.8	

Feed cost—Grain, $49.188; mash, $33.305.
Profit—$140.36.

TABLE 8

Pen 9—1 Per Cent Check

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	231	$10.3488	165	58.0	2.863
September	308	16.6012	166	49.6	3.242
October	353	22.5214	185	84.9	3.172
November	231	13.9524	164	73.4	3.142
December	157	7.9756	186	66.9	3.511
January	384	16.9728	176	79.9	3.702
February	427	15.6282	191	92.2	3.919
March	773	24.4268	215	122.0	3.940
April	782	24.7112	175	135.0	3.500
May	763	24.7975	155	97.5	3.450
June	607	20.2131	130	110.0	3.618
Totals	5116	$198.149	1908	969.4	

Feed cost—Grain, $47.70; mash, $28.888.
Profit—$121.56.

TABLE 9

Pen 5—Check

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	185	$8.2880	165	59.90	2.725
September	276	14.8760	175	61.90	3.183
October	344	21.9472	185	86.20	3.349
November	211	12.7444	164	79.75	3.256
December	292	14.8336	186	83.25	3.542
January	392	17.3264	176	83.05	3.774
February	412	15.0792	187.05	95.00	3.787
March	746	23.5736	217	106.45	3.787
April	883	27.9028	180	138.40	3.650
May	887	28.8275	155	120.00	3.500
June	851	28.3383	150	140.00	3.547
Totals	5479	$213.737	1941.05	1053.9	

Feed cost—Grain, $48.526; mash, $31.406.
Profit—$133.80.

TABLE 10

Pen 10—2 Per Cent

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
August	151	$6.7648	153	59.5	2.269
September	208	12.1120	174	61.4	3.156
October	300	19.1400	185	89.1	3.277
November	123	7.4290	163.5	57.1	3.159
December	175	8.8900	186	60.8	3.400
January	257	11.3594	176	66.6	3.740
February	319	11.6754	187	77.9	3.775
March	634	20.0344	210	105.6	3.780
April	761	24.0476	170	118.9	3.600
May	650	21.1250	150	112.1	3.600
June	482	16.0506	120	86.3	3.714
Totals	4038	$158.628	1874.5	896.1	

The Effect of Using Electric Lights on Laying Birds—Project C 2-25

Two pens of S. C. White Leghorn pullets, 100 to a pen, were housed on September 15, 1925, and lights were turned on one pen of pullets November 1, 1925. The system of lights used is known as the "morning lights," i.e., lights were turned on in the early morning and allowed to burn until daylight. The actual time of turning on the lights was as follows: November 1 to 15, 5 a. m.; November 15 to March 15, 4 a. m.; March 15, gradually decreasing to daylight until time of turning off lights entirely, April 1.

The condition of the moult was observed and it was found that there was a slight neck moult in both pens, but a greater number went into a complete moult in the unlighted pen. Tables 11 and 12 give the comparative results on a profit and cost basis, not including the additional cost of lighting and labor.

TABLE 11

Pen With No Lights

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
November	476	$28.7980	392	144	3.405
December	699	35.5092	372	197.7	3.585
January	865	38.1465	372	177.55	3.878
February	878	32.1348	392	181.2	3.943
March	1317	41.6172	403	200	3.862
April	1360	42.9760	360	240	3.85
Totals	5595	$219.1817	2291	1135.45	

Fed cost—Grain, $57.28; mash, $33.84.
Profit—$128.06.

TABLE 12

Pen With Lights

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
November	703	$42.5315	448	144.00	3.425
December	1133	57.5564	434	222.90	3.460
January	1289	56.8449	434	186.10	3.693
February	1104	40.4064	448	184.95	3.614
March	1401	44.2716	434	200.50	3.591
April	1362	43.0392	360	225.00	3.610
Totals	6992	$284.6500	2558	1163.45	

Feed cost—Grain, $63.95; mash, $34.67.
Profit—$186.03.

A Comparison of Two Dry Mash Mixtures for Laying Hens—Project C 3-25

Two pens of S. C. White Leghorn pullets, 50 pullets to a pen, were housed on November 1, 1925, and fed the following mashes:

One pen was fed the regular New Jersey dry mash, which consists of equal parts, by weight, of wheat bran, wheat middlings, corn meal, ground oats and meat scrap (50%)—a nutritive ratio of 1-3.5. The other pen was fed a dry mash consisting of one part, by weight, of wheat bran, two parts corn meal, one part wheat middlings and one part meat scrap (50%), eliminating ground oats entirely—a nutritive ratio of 1-3.9.

Both pens were fed the same grain ration, which consists of equal parts of cracked corn and whole wheat.

The health in both pens was normal and no apparent moulting in either was observed. Tables 13 and 14 give comparative results on a profit and cost basis.

TABLE 13

Pen Fed With Mash Having Nutritive Ratio 1:3.5

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
November	153	$9.2718	210	82.00	
December	214	10.8712	186	110.00	3.943
January	301	13.2741	185	105.10	4.080
February	299	10.9434	201	95.25	4.334
March............	656	20.7296	217	105.85	4.400
April	687	21.7092	175	119.60	4.400
May	687	22.3275	155	99.80	4.350
June	519	17.2827	150	125	3.945
Totals	3516	$126.4095	1470	842.60	

Feed cost—Grain, $36.98; mash, $23.26.
Profit—$66.17.

TABLE 14

Pen Fed With Mash Having Nutritive Ratio 1-3.9

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
November	94	$5.6870	210	78.75	
December	157	7.9756	186	70.35	3.698
January	352	15.5673	176	110.15	4.013
February	421	15.4086	201	70.75	4.292
March	614	19.4024	215	121.10	4.300
April	717	22.6572	175	146.20	4.300
May	779	25.3175	155	104.20	4.275
June	561	18.6813	150	90.00	3.848
Totals	3695	$130.6969	1468	791.50	

Feed cost—Grain, $36.73; mash, $23.59.
Profit—$70.38.

A Comparison of Three Sources of Animal Protein—Project C 4-25

Three pens of Barred Plymouth Rocks, 33 pullets to a pen, were housed on December 15, 1925, and fed the same grain ration i.e., equal parts of cracked corn and whole wheat.

The following mash mixtures were used:

The first pen:

100 pounds of wheat bran.
100 pounds of wheat middlings.
100 pounds of ground oats.
100 pounds of corn meal.
60 pounds of Meato (75% protein).

The second pen:

100 pounds of wheat bran.
100 pounds of wheat middlings.
100 pounds of ground oats.
100 pounds of corn meal.
100 pounds of meat scrap (50% protein).

The third pen:

100 pounds of wheat bran.
100 pounds of wheat middlings.
100 pounds of ground oats.
100 pounds of corn meal.
200 pounds of bone meal (25% protein).

The health in the third pen was below normal because the birds did not consume a sufficient quantity of the dry mash, and as the amount of scratch ration was regulated, the body condition of the birds became thin.

Tables 15 to 17 give the comparative results obtained on a profit and cost basis.

TABLE 15

First Pen

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
December	188	$9.5504	120	42.8	5.468
January	257	11.3337	156	85.7	5.985
February	299	10.9434	176	104.5	6.138
March	420	13.2720	176	98.4	6.200
April	443	13.9988	175	80.8	6.250
Totals	1607	$59.0983	803	412.2	

Feed cost—Grain, $20.08; mash, $13.77.
Profit—$25.25.

TABLE 16

Second Pen

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
December	179	$9.0932	120.0	39.2	5.661
January	295	13.0095	153.6	84.1	5.986
February	192	7.0272	176.0	89.0	6.125
March	445	14.0620	176.0	96.6	6.150
April	405	12.7980	175.0	71.8	6.150
Totals	1516	$56.1899	800.6	380.7	

Feed cost—Grain, $20.02; mash, $11.34.
Profit—$24.83.

TABLE 17

Third Pen

Month	Eggs	Value	Grain	Mash	Average Weight
			pounds	*pounds*	*pounds*
December	157	$7.9756	120.0	34.8	5.629
January	196	8.6436	148.4	67.7	6.075
February	194	7.1004	176.0	58.5	6.020
March	212	6.6992	176.0	57.3	6.020
April	286	9.0662	175.0	67.2	6.000
Totals	1045	$39.4850	795.4	285.5	

Feed cost—Grain, $19.89; mash, $7.79.
Profit—$11.81.

POULTRY PATHOLOGY

F. R. BEAUDETTE AND J. J. BLACK

The scope of the work done by the poultry pathology laboratory has increased over the previous year. This is particularly true of the South Jersey Laboratory located at Vineland. A larger number of birds have been examined for diagnostic purposes and the increase in the number of tests for "carriers" of bacillary white diarrhea almost doubled last year's number. The experimental projects have likewise progressed very favorably. The work of the two laboratories will be described separately.

New Brunswick

Diagnostic

Laboratory Cases—This classification is made of specimens sent in or brought to the laboratory from this or surrounding states. Such specimens are carefully autopsied and every effort is made to diagnose the disease. In this classification 1,123 birds which originated from 407 different farms were examined. In this number of specimens a total of 1,466 diseases were found. The distribution of these diseases with regards to age and sex is given in table 1. Of the 407 cases thus handled, 379 originated in New Jersey and 28 were sent in from surrounding states. The distribution by counties of those originating in New Jersey and by states of those originating from without the state is given in table 2.

It will be observed that bacillary white diarrhea is the most common infectious disease. Fowl cholera and fowl typhoid continue to be very common. For the first time *B. aertrycke* was found to be the cause of an infectious disease of young chickens. Three outbreaks were located and the loss in them was quite heavy. Such diseases as bronchitis and diphtheritic largyngitis seem to be increasing in frequency. Of the protozoan diseases, black head is being found more frequently in chickens.

TABLE 1

Distribution of Diseases in 407 *Laboratory Cases* (837-1243)

Disease	Cocks	Cockerels	Hens	Pullets	2 weeks 3 months	Under 2 weeks	Duck	Pig		Goose	Turkeys	Total
Cholera	1		6	18			2			3		30
Fowl typhoid			5	1		5						11
B. White Diarrhea		1	3	4	9	226						243
Ovarian B. W. D			1	3								4
B. aertrycke					3							3
Tuberculosis			2									2
Aspergillosis			1							1		2
Botulism			1	1								2
Bronchitis	1		2	38	5							46
Pneumonia		1		1								2
Diph. larngitis		1		29								30
Ocular roup				12								12
Diph. roup				6								6
Simple cold				6								6
Phos. poisoning			1						*1		1	3
Poisoning				5								5
Blackhead	1			8	27	3						39
Coccidiosis		1	1	41	81							124
Flagellatosis				2	1							3
A. persipicillum		10	25	104	7							146
Nematodes (?)									†1	1		2
Heterakis pappillosa		8	6	76	5							95
Capillaria			2	10	1			1				14
Tetrameres (?sp.)		1		8								9
Tapeworms		4	10	74	4							92
Abscess		1	3	4	1							9
Bumblefoot			1	1								2
Red mites			2									2
Con. tissue mites			2									2
Infect. in ear			1									1
Nutritional disease			4	8								12
Rickets				2	2							4
Gout Visceral			2	6	18							26
Paralysis			2	2	7							11
Spleenitis				1								1
Nephritis			1	2								3
Catarrhal enteritis			5	14			1					20
Hemorrhagic enter.				2								2
Crop bound			1									1
Pendulous crop			1									1
Ulcer of prov.				1								1
Ascites				2								2
Atrophy of liver			1									1

*One cat. †One rabbit.

TABLE 1—(*Continued*)

Disease	Cocks	Cockerels	Hens	Pullets	2 weeks 3 months	Under 2 weeks	Duck	Pig		Goose	Turkeys	Total
Leukemia			3	5								8
Cystic ovary			1									1
Egg mass and concretions			2	5								7
Distention of Bursa of Fab...			1									1
Hypertrophy of heart	1			1								2
Internal hemorrhage			1	1								2
Lice			3	3								6
Tumors			8	12								20
Accidental			1		5						1	7
Cellulitis of leg				1								1
Under observation						95						95
Decomposed (not exam.)				7	5	19					2	33
Not diagnosed	1	9	16	45	59	115	4			1		250
Totals	5	37	128	573	240	463	1	1		6	4	1466

No. of birds examined, as laboratory cases	1123
Reported with 2 diseases, 113	113
Reported with 3 diseases, 67	134
Reported with 4 diseases, 20	60
Reported with 5 diseases, 9	36
Total	1466

TABLE 2

Origin of Laboratory Cases (837-1243)

By counties in New Jersey:

Atlantic	6
Bergen	30
Burlington	9
Camden	12
Cape May	1
Cumberland	4
Essex	13
Gloucester	16
Hudson	1
Hunterdon	27
Mercer	37
Middlesex	65
Monmouth	27
Morris	25
Ocean	16
Passaic	10
Salem	10
Somerset	41
Sussex	4
Union	18
Warren	7
	379

Out of State:

New York	17
Delaware	2
Pennsylvania	5
Virginia	2
Maryland	1
Massachusetts	1
	28
Total	407

A parasitic disease of the proventriculus of fowls caused by a nematode was observed several times during the past year. This disease has not been recorded in New Jersey before this year. It will be observed that an etiological diagnosis was not possible in many cases and these are simply listed according to the most outstanding pathological finding. The other diseases require no comment.

Diseases of Cage, Ornamental, and Wild Birds.—As a number of cage, ornamental, and wild birds were received, it was thought advisable to make a separate classification of them. The distribution of diseases in this class is shown in table 3. From an examination of this table it will be observed that *B. aertrycke* infection is the most common disease. A total of 86 specimens were examined.

TABLE 3

Distribution of Disease in Cage, Ornamental and Wild Birds
Cases 1-25

	B. Aertrycke	Hemorrh. enter.	Peritonitis	"Schnappers"	Cut. emphysema	Coccidiosis	Acute gastro-enteritis	Not diagnosed	Total
Goldfinch	1								1
Bullfinch	1								1
Strawberry finch	1							8	9
Canaries	25	1		4	1			19	50
Mule canary	1								1
European siskin	1								1
Shama thrush				1					1
White canary	1								1
Gray Java								4	4
Japanese robin								1	1
Myrtle warbler								1	1
Cardinal								2	2
Song sparrow								1	1
Starling						1			1
Unknown								3	3
Parrot	1								1
Greenshell peroq.								1	1
Swan							3		3
Pheasant								1	1
Peacock		1	1						2
Totals	32	2	1	5	1	1	3	41	86

Number of birds examined, 86.

Cases by Letter.—This classification constitutes such cases as are handled by correspondence. The method is not at all satisfactory in most cases and persons inquiring for information regarding poultry diseases are given temporary recommendations with instructions to send specimens to the laboratory for examination so that the exact nature of the disease may be determined. The number handled in this way was 387. Of these, 239 originated in New Jersey, 143 from other states, and 5 from foreign countries. The distribution of these cases is shown in table 4.

Cases from College Farm.—This classification constitutes the examination of specimens coming from the College Farm. The distribution of diseases in these specimens is shown in table 5.

TABLE 4

Distribution of 387 Cases Handled by Letter (883-1269)

By counties in New Jersey:	
Atlantic	12
Bergen	15
Burlington	5
Camden	15
Cumberland	12
Cape May	0
Essex	14
Gloucester	18
Hudson	1
Hunterdon	27
Mercer	22
Middlesex	11
Monmouth	18
Morris	15
Ocean	15
Passaic	2
Salem	4
Somerset	13
Sussex	2
Union	14
Warren	4
	239

Foreign:	
Canada	1
England	1
France	1
Mexico	1
Panama	1
	5

Other States:			
Alabama	2	New Hampshire	3
California	4	New Mexico	1
Colorado	1	New York	35
Connecticut	6	North Carolina	6
Delaware	7	Ohio	4
Florida	1	Oregon	2
Georgia	1	Pennsylvania	16
Illinois	4	Rhode Island	1
Indiana	3	Tennessee	2
Iowa	1	Texas	1
Kansas	4	Virginia	10
Kentucky	2	Washington	3
Maine	1	West Virginia	1
Maryland	2	Washington, D. C.	1
Massachusetts	7		
Michigan	6		143
Missouri	4		
Nebraska	1	Total	387

TABLE 5

Distribution of Diseases in 33 College Farm Cases (221-253)

Disease	Cock	Cockerel	Hen	Pullet	Baby Chick	Duck	Total
W. Diarrhea			1				1
Ovarian B. W. D.			1	1			2
Bronchitis		2	4	9			15
Diph. laryngitis				8			8
Ocular roup				2			2
Diph. roup				1			1
Mycosis				1			1
Pneumonia			1				1
Necrocis of crop				1			1
Imp. of L. int.					1		1
Cat. enteritis			3	4			7
Prolapsis				1			1
Pendulous crop			1				1
Nephritis				2			2
Peritonitis			1	1			2
Abscess in chest	1	1		1			2
Hemorrh. enteritis		1	1				2
Internal hemorrh.			2	2			4
Leukemia				2			2
Wry neck				1			1
Visceral gout				2			2
Egg bound			1				1
Ascaridia pers.			1	1			2
Heterakids			1	2			3
Tapeworms				1			1
Tetrameres sp.		1	1	3			5
Not diagnosed			4	1	3	1	9
Totals	1	5	23	47	4	1	81

Number of birds examined	62
Reported with 2 diseases, 11	11
Reported with 3 diseases, 4	8
Total	81

Educational

The classification "Educational" constitutes trips made to poultry and veterinary associations for the purpose of giving talks on poultry diseases. The following trips were made:

POULTRY ASSOCIATIONS

New Jersey:		*Other States:*	
Atlantic County	2	New York	1
Bergen	2	Kansas	1
Cumberland	1		
Essex	1		
Gloucester	1		
Mercer	3		
Monmouth	2		
Somerset	1		

VETERINARY ASSOCIATIONS

New Jersey	1	Pennsylvania	1

Experimental

Four experimental projecst are being carried on as follows:

The Diagnosis of Poultry Diseases Occurring in New Jersey—B-1-23.

The project is continuous in that the material is taken from specimens presented for diagnosis. The project records the various diseases that are found in this state. Occasionally new diseases are found and these are thoroughly investigated. At the present time an investigation is being made of an infection caused by *B. aertrycke*. This infection was previously found in many cage birds and in pigeons but was not determined in chickens until this year. Three outbreaks have been found and the organisms isolated from them are being subjected to careful study in comparison with strains from other hosts. A nematode infesting the proventriculus was encountered on several occasions and probably some work will be done in order to determine the intermediate host. A similar parasite affecting aquatic birds is known and its intermediate host (Daphnia) could not have been present under the conditions maintained on poultry plants where this parasite was found in chickens, hence it is thought that perhaps the parasite has another intermediate host. A form of paralysis is being met with, which appears to be a specific disease not associated with parasite infestations and an attempt is now being made to transmit this disease. Thus far the results have been negative. The occurrence of fowl typhoid in baby chicks was frequently encountered during the past year. A study has been made to determine whether this disease is transmitted through the egg. At the present time a flock of fowls is under observation.

A Study of Ascaridia perspicillum—B-2-23.

A study was made of the resistance of the eggs of *A. perspicillum* to the common disinfectants. Embryonated eggs were placed in soil and treated with some of the common disinfectants; later worm-free birds were placed on the soil and after varying intervals the specimens were killed and examined for the presence of Ascarids. In this experiment, which is completed, it was found that a 1-1000 solution of bichloride of mercury, a 5 per cent solution of formaldehyde, and a 5 per cent solution of hydrochloric acid did not affect the eggs of *A. perspicillum,* for the experimental birds placed on infected soil treated with these agents became infested as did the birds which were on untreated infected soil. However, it was found that birds placed on infected soil treated with a 5 per cent solution of phenol remained free of nematodes.

Experiments are also under way to devise methods of rearing fowls in confinement for the control of intestinal parasites. The chicks are never allowed on the ground, but do have the run of a concrete slab extending out 10 feet from the house. One lot of chicks reared in this manner is enclosed by screen runs and in screened houses to exclude all possible carriers of tapeworms.

Finally, a control lot is being reared on the ground under usual conditions. The three lots, when matured, will be placed in as many laying houses and each lot will be divided equally. Half of each lot will be supplied with warm quarters during the colder months of the year. The aim of the experiment is to determine the influence of worm infestations and chilling on mortality and diseases as well as on egg production, etc. The lot of birds reared in confinement and under screens should be free of both round and tapeworms, as well as of coccidiosis and of blackhead whereas those reared only on concrete without screening may be infested with tapeworms, and those reared on the ground may have any one of or all the parasites.

The Relation of Soil Reaction to the Infectious Poultry Disease Organisms—B-4-23.

At present a study is being made of the effect of acid soils on the viability of *Bact. sanguinarium.* It has been found that *Bact. sanguinarium* will not live a week in a soil as acid as pH 6.2 or lower, while the organism in soil of pH 7.0 is still viable after sixteen weeks.

A Study of Avian Paratyphoid Organisms—B-5-25.

This project was instituted for the purpose of determining the distribution of paratyphoid infection in birds, with the idea that perhaps it might ultimately be found in the domestic fowl. Prior to the past year the infection has been found in canary birds and pigeons and this stimulated a further interest. The infection has since been determined in the goldfinch, bullfinch, strawberry finch, mule canary, European siskin, white canary, and parrot. The strains isolated from the various hosts have been undergoing a careful study. Finally, as was expected, the infection was found in young domestic fowls and these strains are being studied in comparison with those isolated from cage birds.

Control Work

Bacillary White Diarrhea Testing.—In 21,241 birds tested at New Brunswick, the distribution of infection is as follows:

	No. tested	Reactors	Non-reactors	Infection
Certified				
				Per cent
S. C. W. Leghorns	10,640	211	10,429	1.98
S. C. R. I. Reds	1,317	224	1,093	17.00
R. C. R. I. Reds	30	1	29	3.33
B. P. Rocks	2164	172	1,992	7.94
W. P. Rocks	693	118	575	17.02
Part. Rocks	41	9	32	21.95
W. Wyandottes	407	52	355	12.77
W. Orphingtons	55	6	49	10.90
Buff Orphingtons	5	0	5	0
J. B. Giants	4,699	998	3,701	21.23
Not certified				
Miscellaneous	1,190	124	1,066	10.42
Totals	21,241	1915	19,326	9.01

Contagious Abortion in Cattle.—The college dairy herd was tested twice for "carriers" of contagious abortion. On January 7, 1926, 104 animals were tested and on March 8, 1926, 102 were tested.

There were 18 requests made for cultures of poultry pathogens by other laboratories and to these were sent a total of 87 strains.

Vineland Laboratory

Laboratory

TABLE 1

Distribution of Diseases in 353 *Laboratory Cases* (176-528)

Disease	Cockerels	Hens	Pullets	2 weeks 3 months	Cockerels	Ducks	Capons	Turkeys	Total
Tapeworms	25	16	124	4		8			177
Ascaris	29	28	130	19		4			210
Capillary			9						9
Heterakis	23	21	122	9		4			179
Coccidiosis	5		44	125		2			176
Blackhead			1	5				4	10
Cholera							2		2
F. Typhoid		4							4
B. W. Diarr.				9	48				57
Pneumonia		1	10	27	66			2	106
Pox			12						12
Canker	2	8	21						31
Roup		2	5	5					12
Cold	1	2	6						9
Int. hemorr.		2	7	1					10
Ext. tumor		1	2	1					4
Int. tumor			2						2
Tumor liver		4	8						12
Ovary tumor		2	1						3
Egg mass		1	3						4
Egg ab'd cavity		1	4						5
Prolapsis			4						4
Rup't. rectum		4	14						18
Paralysis			14	3					17
Peritonitis		4	5						9
Cat. enteritis			3	8					11
Kamala (death by)			10	1					11
Injury				2					2
Gout		1	3						4
Rup't. oviduct		3	5						8
Nutrition	1		4	8			2		15
Sour crop			2		1				3
Frost wattles	1								1
Tuberculosis			1						1
Undiagnosed	1	2	7	22	24				56
Totals	88	107	583	249	139	18	4	6	1194

Number of birds examined, 779	779
Reported with 2 diseases, 110	110
Reported with 3 diseases, 120	240
Reported with 4 diseases, 19	57
Reported with 5 diseases, 2	8
Total	1194

Origin of Cases

Counties in New Jersey:	
Cumberland County	260
Atlantic	48
Camden	5
Cape May	13
Salem	22
Gloucester	3
	351

Out of State:	
New York State	1
Delaware State	1
	2
In New Jersey	351
Total	353

Vineland Egg Laying Contest

TABLE 2

Distribution of Diseases in 105 *Cases* (93-197)—*Birds from Vineland Egg Laying Contest*

Disease	Hens	Pullets	Total
Tapeworms	130	12	142
Ascaris	80	18	98
Capillary	26		26
Heterakis	140	7	147
Coccidiosis	58	3	61
Pneumonia		6	6
Bronchitis	2	3	5
B. W. Diarrhea		2	2
Laryngitis		1	1
Canker in larynx		6	6
Roup	1	9	10
Cold		1	1
Ext. hemorrhage		3	3
Int. hemorrhage	6	12	18
Ext. tumor		1	1
Int. tumor	6		6
Tumor of liver	15	17	32
Abscess of liver		1	1
Tumor of ovary	3	4	7
Egg mass	3	6	9
Egg bound	1	1	2
Egg in ab'd. cavity	4	5	9
Prolapsis	1	12	13
Peritonitis	1	6	7
Pericarditis		2	2
Catarrhal enteritis	1	6	7
Ascities	2		2
Injury	1		1
Gout		3	3
Ruptured oviduct		2	2
Impaction proventriculus	1		1
Heat stroke	4		4
Accidental		1	1
Undiagnosed	2	3	5
Strangulated intest.		1	1
Impaction of intest.		1	1
Totals	488	155	643

Number of birds examined	272
Reported with 2 diseases, 45	45
Reported with 3 diseases, 70	140
Reported with 4 diseases, 40	120
Reported with 5 diseases, 14	56
Reported with 6 diseses, 2	10
Total	643

Poultry Farms Visited		Meetings Attended	
Cumberland County	93	Cumberland County	7
Atlantic	5	Atlantic	3
Cape May	8	Cape May	1
	106		11

Cases handled by letter	4
Cases handled by telephone	3

Experimental Work

Kamala Experiment

This work was done to determine the toxic properties of Kamala and the possibilities of its use in commercial flocks. A number of birds were culled and divided into small flocks and treated with Kamala by different methods. In three instances commercial flocks in which tapeworms were known to be present were treated with 1-gm. doses of kamala. The results are as follows:

Culled birds—			
Treated with uncoated capsule	157	Mortality	54
Treated with coated capsule	98	Mortality	4
Commercial flock—			
Treated with uncoated capsule	80	Mortality	21
Treated with coated capsule	256	Mortality	21

Kamala was found to be a severe treatment and when given after fasting or without fasting, in plain gelatin capsules, a high mortality resulted. When the capsules were coated with any material that prevented the liberation of the drug in the crop and the treatment followed with salts, only those birds died that were affected with other conditions as tumors, ovarian abnormalities, visceral gout, etc. In all cases where laying birds were treated, egg production stopped for two weeks. The culled birds treated were in very poor condition and probably would have died in a short time. The majority of the birds recovered and were returned to the laying flock or sent to market.

To determine intermediate hosts of tapeworms, 100 chicks are being brooded in confinement under screens. These chicks are to be used in studying possible intermediate hosts of tapeworms. Many kinds of suspected hosts, which will be fed to worm-free chicks, will be obtained from plants known to be infested with tapeworms. Later the chicks will be killed and examined for the presence of worms.

Bacillary White Diarrhea Control Experiment

Bacillary White Diarrhea Testing, 1925-26—

Certified birds tested	19,707
Non-certified birds tested	11,732
	31,439

In the year 1924-25, a flock of 59 birds was tested for carriers of bacillary white diarrhea and the following year 9 of the remaining birds and 29 of the offspring reacted. A second retest was made in the second year, 11 weeks following the first test of that year. The results are as follows:

1924-25 Test	Tested	Reactors
Females	55	10
Males	4	0
1925-26 Test		
Retested hens	15	8
Retested cocks	3	1
Pullets	40	28
Cockerels	3	1
1925-26 Retest, 11 Weeks Later		
Retested hens	9	4
Pullets	13	1
Males	3	0

Total Number and Classification of Cases Handled at the New Brunswick and Vineland Laboratories

Classification of cases	Laboratory	No. of cases	No. of birds	No. of diseases found
Laboratory	New Brunswick	407	1123	1466
College Farm	New Brunswick	33	62	81
Cage, ornamental and wild birds	New Brunswick	25	86	86
Letter	New Brunswick	387		
Vineland contest	Vineland	105	272	643
Laboratory	Vineland	353	779	1194
Visit	Vineland	106		
Letter	Vineland	4		
Telephone	Vineland	3		
		1423	2322	3470

Total Number of Blood Tests

Bacillary white diarrhea	52,680
Contagious abortion	206
	52,886

Report of the Department of Seed Analysis

INTRODUCTION

The seed control laboratory has carried on its two main lines of work as in previous years. The character of this work is two-fold. There is a free analysis of seeds for farmers, growers, and other residents of the state, and an inspection and analysis of samples of seed as they are sold in the open market. The former type of work is classed as unofficial, the latter as official. The unofficial analyses continue as in previous years to outnumber the official tests and constitute the most popular phase of the work of the seed laboratory. The continued demand for the free analytical service and the successful and effective operation of the law, prove the worth of the laboratory as an agricultural agency in the state.

ADMINISTRATION

The New Jersey Seed Law is a liberal, workable statute regulating the sale of bulk quantities of seed sold in New Jersey markets. Twice yearly all dealers in the state, handling bulk quantities of crop or vegetable seeds, are visited. The entire stock of these dealers is examined. A portion of the lots is sampled and these samples are analyzed and reports of laboratory findings made to the local vendors. In such a way the activities of the seed trade within the state are watched and checked up.

A portion of the administrative duties of the department is the inspection and sampling of stocks of legume inoculant materials handled by local dealers in the state. Culture materials of various kinds have been manufactured over a period of years and are offered for sale for the purpose of the inoculation of leguminous plants. It has been found that very little unguaranteed material is for sale at the present time.

SEED INSPECTION

Official Samples

The yearly seed inspection of dealers' stocks was started about March 1, at the time the seeds came in from the shippers. To date, 1,425 official samples have been collected and analyzed. This number does not represent the total amount for the year, as there will be a fall inspection of cover crop seeds, when between 200 and 300 samples will be examined. Every sample tested is reported to the dealer. This report states whether the seed is in compliance or in violation of the law and gives the exact ingredients contained therein. A clearer understanding of the significance of the seed law and its operation is apparent among dealers. Numbers of violations decrease yearly and the amount of unlabelled stock grows continuously smaller. Much greater care is exercised by dealers in handling their stock, and much more checking up of tests between wholesalers and retailers is carried on than in former years. All this cooperation means a better product for the farmer. The buying of seed in market is not a hazard as it was prior to required labelling because not only the variety but the quality of the seed in terms of purity and germination is given. It remains only to educate the general public to look for these percentage figures and to give them an idea of their meaning, before the intended mechanism of the law will be in full operation. A larger number of official samples have been collected to date than in any previous year. The total inspection will undoubtedly be greater.

Unofficial Samples

Unofficial sample tests are of two general kinds, crop seeds and vegetable seeds. These samples are sent in by farmers and residents of the state. Beyond question this is the most beneficial service rendered by the laboratory. These samples are representative of all types and kinds of seeds. Some of the seed is old seed carried over from previous stock or a previous purchase. Some of the seed is new and the farmer or buyer is anxious to know the quality before purchase. In order to satisfy the demand and to make this feature of the work profitable and valuable to the inquirer, tests must be conducted as promptly as possible. This expediency demands adequate equipment and expert analysts in sufficient numbers to handle requests in the shortest possible time. Accordingly, another full time analyst was added to the staff this year. Many times only a few days intervene between the sending of the sample to the laboratory and the planting of the crop in the field. Consequently if the information is to be valuable to the sender it must be given immediately. Many more requests of a technical nature have come to the laboratory this year. Testing of lawn mixtures has constituted an important part of the work. As New Jersey becomes more and more of a suburban state made up of cities and towns, the seed laboratory must handle increasing numbers of lawn seed samples. The ingredients of these mixtures are often questioned and an exact determination of species is necessary. Questions of determinations between lawn and pasture mixtures have been asked.

The importance of the free analytical service cannot be emphasized too greatly as the continued demand for assistance of this kind demonstrates its value.

Table 1 gives the number, kind, and average percentages of unofficial seed samples analyzed from July 1, 1925 to July 1, 1926.

TABLE 1

Number of Unofficial Samples Tested—1925-26

Kind of seed	Number of samples tested	Average purity	Average germination
		per cent	*per cent*
Grasses and Cereals			
Timothy	36	99.58	89.85
Red Top, fancy	24	88.21	89.75
Red Top, chaffy	3	35.06	70.17
Orchard grass	35	87.80	77.96
Kentucky Blue Grass	9	75.78	54.69
Canada Blue Grass	4	81.50	64.17
Chewings Fescue	1	92.08	35.50
Red Fescue	8	90.05	62.29
Hard Fescue	1	90.36	84.00
Miscellaneous Fescue	19	86.12	51.03
Crested dog's tail	6	98.61	52.10
Rye grass	11	99.20	81.44
Sudan grass	4	97.18	86.25
Oat grass	1	84.93	84.00
Bent grass	6	54.44	63.80
Miscellaneous grasses	15	80.09	76.29
Grass mixtures	46	74.03	....
Millet	4	98.22	86.50
Field corn	46	....	95.24
Oats	6	95.46	93.17
Rye	7	97.57	68.50
Wheat	3	....	93.63
Barley	2	98.08	83.00
Leguminous Forage Crops			
Alfalfa	74	98.96	83.00
Alsike clover	33	97.89	86.55
Red clover	56	98.51	88.21
Crimson clover	14	96.71	82.04
Sweet clover	24	98.28	84.63
White clover	6	96.99	86.33
Vetch	21	98.65	79.83
Soybeans	15	97.10	89.57
Canada field peas	11	89.24	94.09
Cowpeas	5	98.38	61.40
Miscellaneous Forage Crops			
Rape	4	97.21	64.63
Tobacco	1	....	72.50
Vegetables			
Artichokes	2	....	71.50
Asparagus	25	....	84.82
Beans	213	....	87.03
Beets	133	....	*74.14 †144.14
Brussel sprouts	6	....	75.25
Cabbage	139	....	73.19
Carrots	74	....	60.14

TABLE 1—*Continued*

Kind of seed	Number of samples tested	Average purity	Average germination
		per cent	*per cent*
Cauliflower	10	....	72.95
Celery	90	....	61.67
Celeriac	9	....	65.89
Chervil	2	....	65.00
Chicory	1	....	54.00
Collards	2	....	81.00
S. Corn	78	....	84.51
Corn salad	2	....	60.50
Cress	7	....	31.58
Cucumber	78	....	88.61
Dill	5	....	61.50
Eggplant	54	....	74.66
Endive	21	....	65.17
Kale	17	....	72.53
Kohl rabi	11	....	72.23
Leek	13	....	79.73
Lettuce	173	....	83.34
Mangels	4	....	*61.50 †127.00
Muskmelon	78	....	84.44
Mustard	1	....	92.50
Okra	14	....	71.50
Onion	119	....	57.00
Parsley	43	....	50.79
Parsnips	15	....	44.77
Peas	148	....	86.25
Pepper	40	....	63.39
Pumpkin	53	....	73.20
Radish	107	....	79.07
Rutabaga	16	....	66.75
Salsify	8	....	52.00
Spinach	116	....	51.85
Squash	76	....	77.46
Swiss chard	23	....	*76.48 †167.57
Tomato	95	....	81.22
Turnip	71	....	75.44
Watermelon	63	....	74.76
Miscellanous	35	....	50.83
Dandelions	4	....	29.75
Flowers			
Nasturtium	15	....	74.60
Sweet Peas	20	....	64.38
Miscellaneous	26	....	63.38
Total	2916		

*Bolls. †Sprouts.

Plant Identification

Numbers of plant identifications are made yearly by the department. Some of these determinations are made from plant structures, others are made from the seed alone. Occasional crop plant identifications are necessary and crop seed identifications are numerous. This work, it is believed, is an indispensable adjunct of the department. Frequently plants of a noxious nature are identified. Many times a farmer knows the harm which these noxious weeds do in his fields but he recognizes them from reputation only. This

TABLE 2

Identification of Plants

Common Name	Botanical Name	Source
Horsetail	*Equisetum arvense*	Basking Ridge, N. J.
Horsetail	*Equisetum arvense*	Paterson, N. J.
Crab Grass	*Digitaria sanguinalis*	Plainfield, N. J.
Silky Wild Oat	*Danthonia sericea*	New Brunswick, N. J.
Salt Marsh Grass	*Phragmites Phragmites*	Staten Island, N. Y.
Canada Blue Grass	*Poa compressa*	New Brunswick, N. J.
Quack Grass[1]	*Agropyron repens*	Woodbury, N. J.
Ironwood	*Ostrya virginiana*	New Brunswick, N. J.
Veined Dock	*Rumex venosus*	Philadelphia, Pa.
Knotweed	*Polygonum aviculare*	Newark, N. J.
Common Pigweed	*Amaranthus retroflexus*	Woodbury, N. J.
Knawel	*Scleranthus annuus*	Paterson, N. J.
Thyme-leaved Sandwort	*Arenaria serpyllifolia*	Silver, N. J.
Mouse-ear Chickweed	*Cerastium arvense*	New York, N. Y.
Mouse-ear Chickweed	*Cerastium vulgatum*	Paterson, N. J.
Bladder Campion	*Silene latifolia*	Morristown, N. J.
Field Pepper Grass	*Lepidium campestre*	Wappingers Falls, N. Y.
Shepherd's Purse	*Capsella Bursa-pastoris*	Paterson, N. J.
Charlock	*Brassica arvensis*	Little Silver, N. J.
Common Yellow Rocket	*Barbarea vulgaris*	New York, N. Y.
Red Haw	*Crataegus sp.*	Millville, N. J.
Five Finger	*Potentilla arguta*	Trenton, N. J.
Honey or Sweet Locust	*Gleditsia triacanthos*	Shrewsbury, N. J.
Trailing Tick-Trefoil	*Desmodium glabella*	Titusville, N. J.
Cranesbill	*Geranium maculatum*	Mount Holly, N. J.
Spotted Spurge	*Euphorbia maculata*	Mount Holly, N. J.
Box Elder	*Acer Negundo*	Mays Landing
Bladder Ketmia	*Hibiscus Trionum*	Titusville, N. J.
Evening Primrose	*Oenothera laciniata*	Bridgeton, N. J.
Deerberry or Buckberry	*Vaccinium stamineum*	Skillman, N. J.
Fool's Parsley	*Aethusa Cynapium*	Shrewsbury, N. J.
Dodder[1]	*Cuscuta arvensis*	Bernardsville, N. J.
Gill-over-the-ground	*Nepeta hederacea*	Little Silver, N. J.
Self-heal or Heal-all	*Prunella vulgaris*	Pennington, N. J.
Self-heal or Heal-all	*Prunella vulgaris*	Pennington, N. J.
Henbit	*Lamium amplexicaule*	Little Silver, N. J.
Field or Corn Mint	*Mentha arvensis*	Shrewsbury, N. J.
Sand Bur	*Solanum rostratum*	Palisades Park, N. J.
Ground Cherry	*Physalis sp.*	Mays Landing, N. J.
Paulownia	*Paulownia tomentosa*	Shrewsbury, N. J.
Paulownia	*Paulownia tomentosa*	Staten Island, N. Y.
Cleavers	*Galium Mollugo*	Bernardsville, N. J.
Indian Tobacco	*Lobelia inflata*	Shrewsbury, N. J.
Small White Snakeroot	*Eupatorium aromaticum*	New Brunswick, N. J.
Golden Rod species	*Solidago sp.*	Mount Holly, N. J.

[1] Noxious weeds.

phase of the seed laboratory work, while strictly botanical, has a practical and economic value, and investigation along these lines is encouraged insofar as cooperation and prompt attention to requests will develop it. The weed situation becomes more serious yearly through the spreading of weeds. Seed analysis has prevented in great measure the dissemination of weeds through the agency of seeds. There is still the problem of educating the general public to the damage weeds actually cause to property.

The first step in this process is to acquaint people with the common and noxious kinds of weeds and their characteristics, so that they can distinguish them. The methods of eradication or control should then follow.

A record of all weeds identified at the laboratory has been kept over a series of years. This systematic record enables the laboratory to trace a weed infestation and to know its occurrence and distribution. It also gives plants which are most generally troublesome. Table 2 gives the common and botanical names of plants identified and the sources from which they came.

Legume Inoculation

Official samples of legume inoculants are collected twice yearly from the local dealers in the state. The results of the tests of these samples are reported in connection with the official seed report. Samples sent in by farmers or other interested parties are classed as unofficial.

Twenty-one unofficial samples were analyzed during the fiscal year. As with the seed samples, they represent all types of material of different composition and age. Consequently the results are varied both in culture and soil tests. Table 3 gives a summary of the results of unofficial tests.

Table 3

Number of Unofficial Inoculant Samples Tested—1925-26

Kind of Seed for which Inoculant is prepared	Number Samples Tested	Average Number Organisms per package*	Purity	Growth on Plants
Alfalfa, Sweet, Bur, and Hubam Clovers	3	78,666,000	O.K.	Good
Red Clover	1	50,000,000	O.K.	Good
Cowpeas	1	28,000,000	O.K.	Poor
Winter and Spring Vetch	2	216,000,000	O.K.	Very Good
Soybeans	2	33,000,000	Contaminated	Poor
Garden Peas	5	527,000,000	O.K.	Good
Garden Beans	4	73,500,000	O.K.	Good
Serradella	1	256,000,000	O.K.	Very Good
Lupines	1	46,000,000	O.K.	Good
Peanuts	1	52,000,000	O.K.	Good
Total	21			

*For the inoculation of 1 acre.

Report of the Sewage Substation[1]

WILLEM RUDOLFS

INTRODUCTION

With the progress made from year to year on fundamental studies of the biology of sewage disposal it becomes more and more apparent that the information gathered will ultimately lead to decided improvement of existing systems of sewage disposal and will also pave the way for new, thoroughly understood methods. Considerable information has been obtained during the fiscal year on the effect of environmental conditions upon the speed of sludge digestion and the feasibility of controlling these conditions. Particular attention has been paid to the influence of reaction of the material and the effect of temperature on the rapidity of digestion. As far as the writer is aware, information regarding these two factors is extremely meager or totally absent. The fact that with a certain adjustment of the medium not only is digestion time reduced, but also the type of digestion is influenced or can totally be changed, is ample evidence that the possbiilities of improving existing systems and of establishing new methods of anaerobic digestion are real. These questions have left the realm of speculation and we are on the threshold of a new phase of sewage disposal, namely, that of scientific control. In connection with scientific plant control, the writer is pleased to be able to record that in addition to the most fruitful cooperation of the superintendent of the Plainfield plant the department has begun cooperative experiments on separate sludge digestion on a large scale with the City of Baltimore at their Back River sewage disposal plant.

During the year it has become more and more apparent that our methods of studying the different groups of bacteria are totally inadequate. To be sure, the data obtained by these methods have given us considerable general information regarding the course of digestion which fresh solids take under different conditions, but for a real insight into the possible types of anaerobic digestion more refined methods have to be worked out. There are two possible ways to attain this: First, isolation of specific organisms and their study in pure cultures under different conditions; second, studying specific physiological groups of organisms. The classification of bacteria into albumen digesters, H_2S producers, nitrate reducers and cellulose fermenters has failed to show us what types of bacteria are responsible for the digestion at different stages. The reasons are obvious, since many organisms, when transferred into these media, are capable of growing and bringing about changes which they may or may not produce in the course of digestion. The picture obtained, therefore, from a study of the organisms in their culture media does not necessarily correspond to the actual interrelationship of the organisms in the course of digestion. As an example, the growth and subsequent production of gas in lactose medium have been taken as an index of the lactose fermenting group; however, widely different groups are able to utilize lactose. Hence, the recording of gas production will not show which organisms in this extremely wide group are really responsible for the action taking place at different stages during the course of digestion. Splitting up this group into aerobic and anaerobic lactose fermenters, spore forming and non-spore forming lactose fermenters, and so on, will enable us to make a beginning in visualizing the types of bacteria responsible for the digestion and to succeed in correlating these with the biochemical changes taking place. A study of specific organisms in pure cultures might give some information regarding their activities under certain conditions, but since we are always dealing with large numbers of different organisms, it is doubtful whether we will be able to obtain the necessary information within a reasonable length of time. A study of specific physiological groups, however difficult, seems at present to promise results more in keeping with the information gathered on the biochemical changes. Our knowledge of intermediate and end products is vastly greater than our knowledge of organisms causing the changes and producing the products.

---

[1] Joint project of the New Jersey Agricultural Experiment Station and the New Jersey State Department of Health, until changed by an act of the Legislature, approved March 17, 1926 (see p. 410 of this report), into the Department of Biology of Sewage Disposal of the New Jersey Agricultural Experiment Station.

The sewage substation created by an act of the New Jersey Legislature in 1920 as a joint project between the New Jersey Agricultural Experiment Station and the New Jersey State Department of Health has been changed by an act passed by the Legislature into a Department of Biology of Sewage Disposal of the New Jersey Agricultural Experiment Station.

Chapter 45, Laws of 1926

Chapter 45

An Act to amend the title and body of an act entitled "An act to authorize the Agricultural Experiment Station and the State Department of Health to investigate the biology of sewage disposal.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

1. The title of the act to which this act is an amendment be and the same is hereby amended so as to read as follows:

An act to authorize the Agricultural Experiment Station to investigate the biology of sewage disposal.

2. The Agricultural Experiment Station of this State shall conduct an investigation of the biology of sewage disposal, to the end that more effective methods of sewage purification may be discovered and applied to the purification of sewage in this State.

3. The said department shall be authorized to expend for such purpose such sums as shall be included in any annual appropriation bill.

4. All acts or parts of acts inconsistent herewith are hereby repealed.

5. This act shall take effect immediately.

Approved March 17, 1926.

Again this year the Chemical Foundation appropriated the sum of $1,000 for studies to be carried on in the sewage substation, while the fellowship established last year by the Dorr Company for specific studies has been continued for another year.

STAFF

Fortunately for the work this year, no changes in the sewage substation staff occurred. This has been the first year all members were employed on full time.

The controlling committee of the substation has again consisted of Dr. T. J. Headlee, representative of the New Jersey Agricultural Experiment Station; Mr. John V. Mulcahy of the New Jersey State Department of Health, and Dr. Willem Rudolfs, Chief of Sewage Investigations.

The research committee of the New Jersey Sewage Works Association consisted of Messrs. H. M. Beaumont, Philadelphia, Chairman; J. R. Downes, Plainfield; Paul Molitor, Chatham; J. R. Riker, Trenton; I. Z. Collings, Collingswood; H. N. Lendall, New Brunswick; C. A. Mitchell, Vineland; and Mr. Chester G. Wigley, Atlantic City, representing the Sanitary Section of the American Society of Civil Engineers.

SCOPE OF INVESTIGATIONS

The investigations have this year been organized into a number of headings:

1. Gross relation between bacterial, zoological, and botanical activities and their chemical end products.
2. Transformation of organic character of sewage into relatively stable end products.
3. Studies on the activity changes of organisms by mechanical means (influence of stirring, washing of sludge, tank design).
4. Effect of environment on sewage sludge digestion (temperature, hydrogen-ion concentration, aeration, chemicals, addition of organic and inorganic materials, etc.).
5. Effect of acidity and alkalinity adjustment on the rate of digestion.
6. Studies on carbohydrate digestion (bacterial groups, effect of chemicals, temperature, effect of carbon-nitrogen ratio).
7. The role of specific groups of organisms (bacteria, protozoa) on the course of digestion.
8. Studies of methods of increasing or decreasing specific groups of organisms (protozoa, bacteria).
9. Disposal of sludge (agricultural value, destruction by burning, distillation) and recovery of valuable products (ammonia, gases, grease, etc.).
10. Study of the fate of intestinal organisms entering digestion tanks, with special reference to the *B. coli* groups.
11. Causes and prevention of odors from sewage disposal plants.
12. Studies of methods to control insect nuisances (psychoda fly, mosquitoes, etc.).

PUBLICATIONS

A number of papers have been published during the fiscal year from the Sewage Substation, and are listed in the Journal Series on page 48-50 of this report.

EFFECT OF LIME ON SLUDGE DIGESTION

W. Rudolfs, H. Heukelekian, P. J. A. Zeller, D. Peterson, J. R. Downes

Introduction

It has been our contention for the last few years that the reaction of the medium is an important factor in sludge digestion. It has been pointed out in previous reports (16, 17) that during the course of sludge digestion several acid materials are formed and that the behavior of Imhoff tanks is often closely related to the reaction of the liquid and sludge of operating digestion compartments. It has been demonstrated again and again that as soon as the sludge or the supernatent liquid in the digestion compartments showed pH values near or below the neutral point, unbalanced conditions existed. The hydrogen-ion concentration measurements showed that when the supernatant liquid became nearly neutral troubles were approaching, and when the liquid registered pH values below the neutral point, troubles were present. We have pointed out that the determination of the hydrogen-ion concentration might be an efficient tool in the hands of engineers and operators provided they would know the optimum reaction for efficient digestion and the means of correcting the medium.

Some preliminary experiments conducted in 1924 showed that the effect of lime under certain conditions was very pronounced. During 1925 a beginning was made on a somewhat exhaustive study, both in the laboratory and at the Plainfield plant, in an effort to throw light upon the effect of lime under different conditions prevailing during digestion. The laboratory experiments were designed to find (*a*) the optimum reaction for most rapid sludge digestion, (*b*) how such an optimum reaction could be maintained, (*c*) whether or not more fresh solids could be taken care of at different reaction, and (*d*) the reasons for the action of chemicals, particularly hydrated lime. The plant experiments were conducted on an Imhoff tank in comparison with untreated tanks and for about six months on a newly constructed separate sludge digestion tank. The results obtained will be discussed separately under different headings.

Laboratory Experiments

Methods

In a series of bottles sufficient ripe sludge was placed to take care of daily additions of 2 per cent. fresh solids (on a dry basis), found to be the maximum that could be added without impairing digestion (18). The bottle contents were adjusted to pH values of 7.2, 7.6, 8.2, and 8.8 by the proper amounts of hydrated lime. To another similarly adjusted series, with the same amounts of seeding material, 3½ per cent. fresh solids were added daily, and to still another series 5 per cent. fresh solids daily.

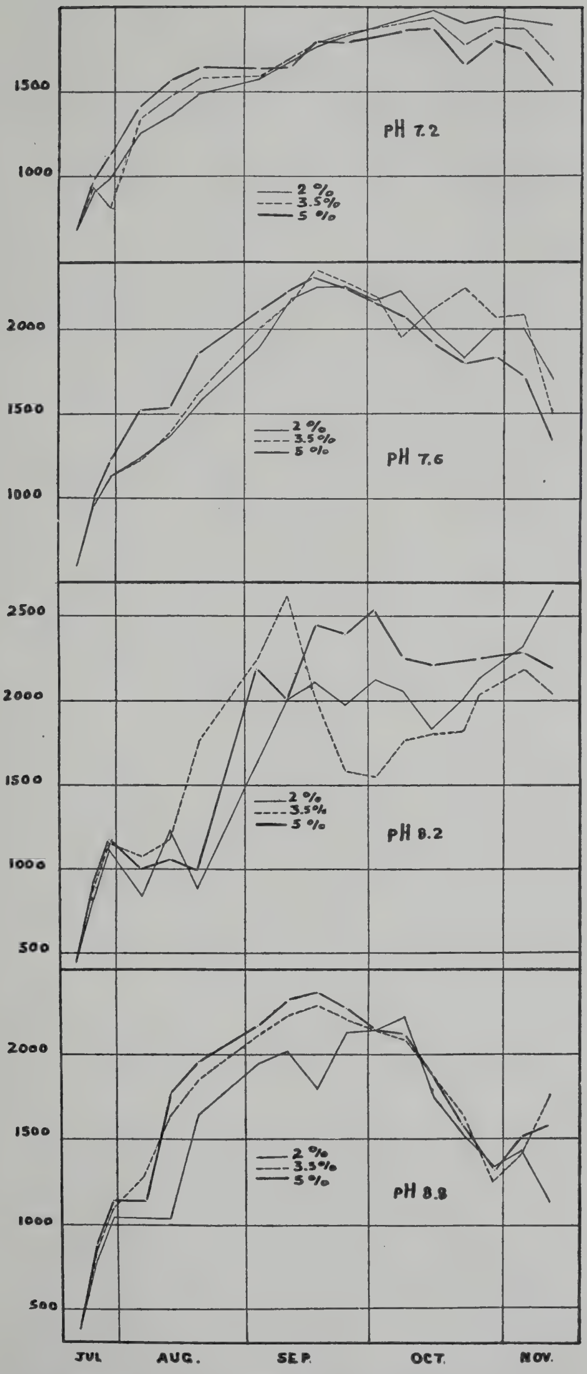


Fig. 1. Total Alkalinity in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values by the Addition of Lime.

The bottles were numbered as follows:

Number	pH	Per cent. Solids	Number	pH	Per cent. Solids
1	7.2	2.0	7	8.2	2.0
2	7.2	3.5	8	8.2	3.5
3	7.2	5.0	9	8.2	5.0
4	7.6	2.0	10	8.8	2.0
5	7.6	3.5	11	8.8	3.5
6	7.6	5.0	12	8.8	5.0

The calculated amounts of fresh solids were added daily, except on Sundays and holidays, but to compensate for these omissions, double portions were added the day following. Once each week a sufficient amount of the bottle contents was withdrawn to maintain a constant volume of material. To determine the changes in pH values caused by the digestive processes, a small sample was withdrawn twice a week and the bottle contents were readjusted to the predetermined hydrogen-ion concentration whenever necessary. Twice a week pH values were determined on the bottle contents, and once a week analyses for carbonates, ammonia, solids, and ash were made. A record was made of the total amounts of fresh solids, their pH values, their total acidities, and the amounts of lime necessary to adjust them to the different pH values. Counts of bacteria were made on agar plates and protozoa were enumerated and the species recorded in the manner used in this laboratory (15).

Results

Chemical

From the beginning of the experiments it was noted that lime added in different amounts had a marked effect on the distribution of the solids between the top and the bottom of the liquid. The solids in all the bottles adjusted to 7.2 and 7.6 remained at the bottom throughout the duration of the experiment, whereas solids in the other bottles were moving continuously from top to bottom and vice versa, usually from ¼ to ⅔ being at the top. This is not only significant for the process of digestion, but also in connection with excessive scum formation. It is well known and has been found repeatedly in our laboratory that solids slightly acid in character will also float to the top and remain there permanently unless the reaction of the material is changed.

Alkalinity.—For convenience of an adequate presentation of the results, the series kept at different reactions will be discussed separately. Total alkalinity, represented in figure 1, shows in the pH 7.2 series a rapid increase during the first month from about 700 p.p.m. to 1500 to 1600 p.p.m. No increase in total alkalinity occurred during the next three weeks, but thereafter again a slight increase occurred. Alkalinity figures are as a rule of no interest after the initial rapid increase. The first increase indicates usually a certain progress in digestion, but as soon as digestion is well under way, the alkalinity curves flatten out. When fresh solids are digested without

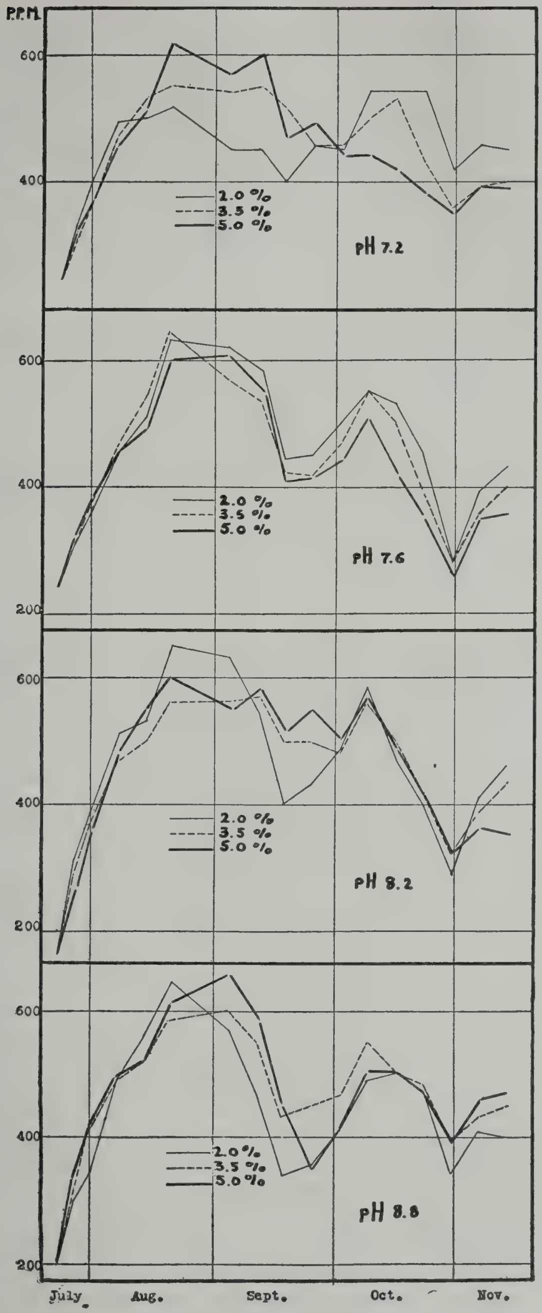


Fig. 2. Ammonia Production in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values by the Addition of Lime

daily additions, the rise of the alkalinity curves is reversed towards the end when digestion is nearing its completion. From the curves it will be noticed that the total alkalinity and shape of the curves is very similar for 2, 3.5 and 5 per cent. additions. It seems thus that, if alkalinity alone could be taken as an index to digestion, practically no more alkaline materials were produced with larger additions than with smaller. It should be kept in mind, however, that total acidity increased with the amount of organic matter present and that alkaline substances may be produced at a faster rate in more concentrated material, but that they neutralize the acids and acid colloids. (See also general discussion, p. 489. In the pH 7.6 series the rise in alkalinity continued for nearly two months to about 2400 p.p.m. and was followed by a drop. This drop occurred in spite of the fact that the pH values were kept as nearly as possible at the same values by the addition of hydrated lime. It is also of interest to note that particularly the bottles receiving 2 and 3.5 per cent. daily additions did not fall below 200 p.p.m. The titrated alkalinity at the end of the second month was perhaps due in part to the lime added, but as a rule the lime was taken care of by the acids formed. The pH 8.2 series presents a different picture in total alkalinity figures. Although large amounts of lime were added during the first two weeks, the rise from about 450 to 1100 p.p.m. was interrupted for nearly 3 weeks, but then was followed by a rapid rise to about the same level as in the pH 7.6 series. However, instead of running parallel for the different solids additions, they diverged widely and the individual curves fluctuated rapidly from sampling period to sampling period. Alkalinity in the pH 8.8 series rose rapidly to a high peak of 2200 p.p.m and dropped at the same rate to 1300 p.p.m during the next month. This drop in alkalinity could not be checked by the large quantities of lime added during this period. That additions of lime do not necessarily increase total alkalinity is shown in figure 1, where the alkalinity of bottles receiving 2 per cent. fresh solids daily and kept at different reactions is compared with the amounts of lime added at given dates. The bottle kept at pH 8.2 shows this very strikingly at the beginning of the experiments, whereas the other examples show it more definitely after 2 months' incubation.

Ammonia-nitrogen.—Figure 2 shows the initial increase and fluctuation in ammonia-nitrogen in the different bottles. It will be seen that in nearly every instance ammonia production reaches its maximum after a little over 3 weeks of incubation. The fluctuation which followed this rise seems to be more or less rhythmic, especially in the pH 7.6 and 8.8 series. Of interest is that the shapes of the curves in the pH 7.6 series are nearly identical for the different solids concentrations. In comparing the curves for total alkalinity with the ammonia curves it will be noticed that the general tendency of the curves is the same, barring the large fluctuations in the latter. In the case of fresh solids digestion experiments without daily additions (17) it was found that ammonia and carbonates production increased rapidly during the first stage of digestion, carbonates decreasing and ammonia-nitrogen remaining constant later on. Cyclic ammonia production did not occur, but observations on ammonia production in Imhoff tanks (16) show fluctuations of a more or less rhythmic character. This would indicate, as has been pointed out before, that the digestion processes are not continuously uniform in rate and possibly not the same in character throughout the duration of the experiments.

Hydrogen-ion Concentration.—The variation in pH values of the contents of the different bottles, together with the amounts of hydrated lime added to adjust the reaction, are presented in figures 3, 4, and 5. It should be kept in mind that in all cases the fresh solids were adjusted to the different hydrogen-ion concentrations before their daily addition to the bottles. The graphs in figures 3, 4, and 5 represent, therefore, the variation in pH values caused by the digestive activities. From figure 3 it can be seen that bottles 1, 2, and 3, intended to be kept at pH 7.0, were nearly always slightly higher, especially at the beginning of the experiment. The average pH value of the whole period of the experiment for the series was 7.2. Because of the digestion processes, which have always a tendency to make the medium more alkaline as soon as the neutral point

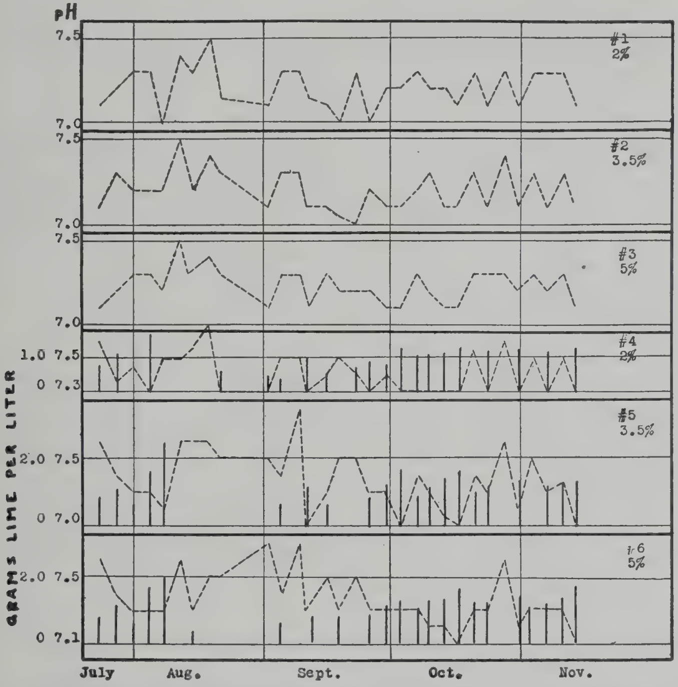


Fig. 3. Comparison of Fluctuations in pH Values and Amounts of Lime Necessary to Maintain the Reaction of the Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily at pH Values of 7.0 and 7.6

is reached, it was practically impossible to retain the bottle contents at exactly 7.0 unless certain acid compounds had been added. It seems thus that adjustment of incoming material to this pH value excludes the necessity of adding lime to the tanks (see also p. 463). The addition of acid compounds was considered undesirable, since this series then could not very well be compared with the other series.

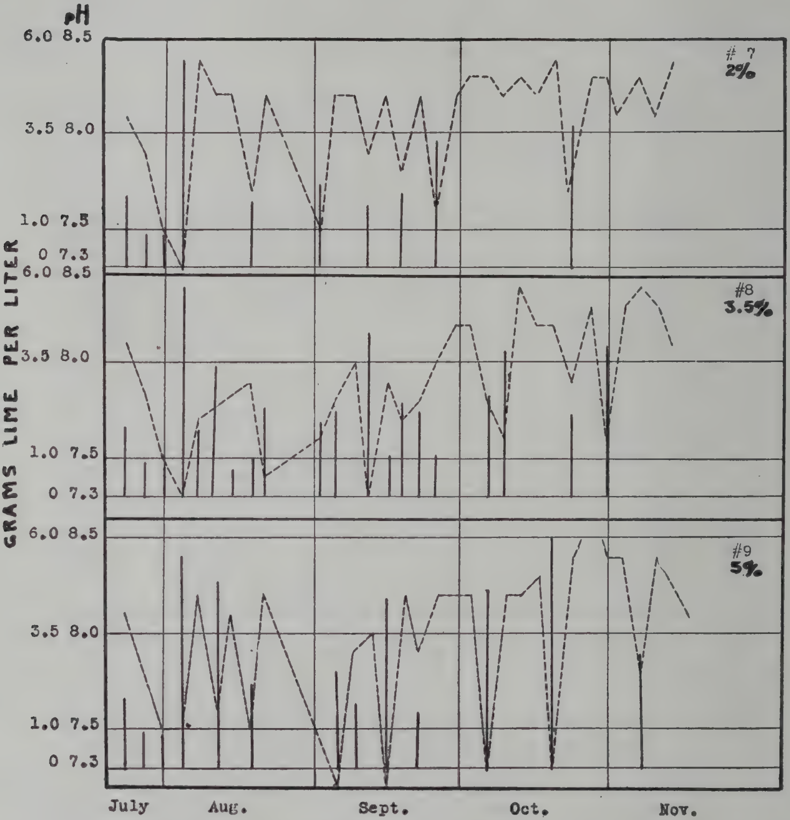


Fig. 4. Comparison of Fluctuations in pH Values and Amounts of Lime Necessary to Maintain the Reaction of the Mixture of Ripe Sludge with Different Amounts of Fresh Solids Added Daily at a pH Value of 8.2

The same difficulty was encountered with all other bottles, but here the tendency was usually toward the neutral point, or rather toward greater acid than alkali production. This is of considerable interest since it tends to show that additions of lime, while neutralizing acid compounds, stimulated acid formation. This question will be discussed later in greater detail (p. 489). Data and curves (fig. 3, 4, and 5) seem to show that after a short time of incubation, rhythmic fluctuations of pH values occurred. Fluctuations in pH values became larger with the increase of solids added, and again differences in pH value from sampling period to sampling period became greater when attempts were made to keep the solids at higher pH values as indicated by the 7.2, 7.6 and 8.2 series. The remarkable uniformity of the pH values in the 8.8 series during the first 2½ months could be caused by one of two reasons: First, an equilibrium in digestion, indicating rapid and desired decomposition; or, second, inhibitory action of the lime used for initial adjustment. In case an equilibrium was established between the organisms with subsequent rapid digestion, the acid compounds would be taken care of by alkaline products as soon as the acid materials were formed. The results would be a continuous, fairly smooth curve during the whole period of digestion. After the first 2½ months, however, fluctuation in pH values became very pronounced. Moreover, other data and ob-

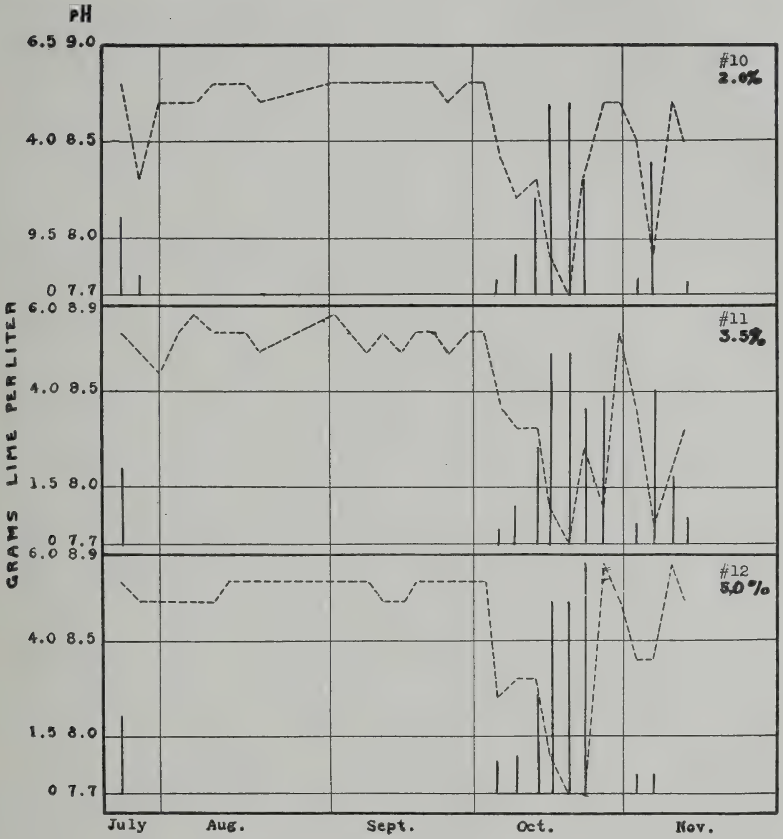


Fig. 5. Comparison of Fluctuations in pH Values and Amounts of Lime Necessary to Maintain the Reaction of the Mixture of Ripe Sludge with Different Amounts of Fresh Solids Added Daily at a pH Value of 8.8

servations show that digestion in this series took place during the first two months at an even rate, but the equilibrium was upset later. It is possible that at this high pH value another optimum for digestion is found, with a different type of digestion than at pH 7.2 to 7.4. The results obtained at pH 8.2 would then indicate a transition stage between the two optima. However, the second part of the experiment indicates clearly that digestion at this pH value does not give persistent good results. From an economic viewpoint digestion at such high pH values seems, at the present state of our knowledge, out of the question unless the entering sewage is so alkaline that with little or no modification such a pH value could be reached. At present we do not feel that evidences are conclusive enough to warrant a statement that digestion is satisfactory at this reaction, especially in view of the strong odors produced.

Odors.—During the course of the experiment particular attention was paid to the odors emanating from the bottles when shaken for samples. Practically no odors were noticed from the 7.2 and 7.6 series at any time. On August 18 a decidedly putrefactive odor has developed in number 7 (pH 8.2 series, 2 per cent. solids addition). On September 7 the odor in this bottle was very bad, and odors had developed in bottles 8 and 9. On October 27 the odor in these bottles was noted as "most vile," for want of a better expression. On November 3 the odor in these bottles was still persistently "very vile" and an odor started to develop in the bottles of the pH 8.8 series. On November 13 the daily additions of fresh solids were discontinued, but analyses were made for some time afterward. On November 20 the bottle contents of the 8.2 and 8.8 series had still very bad odors. From these observations it is of interest to note that odors developed first in number 7, then gradually in 8 and 9, and finally included 10, 11, and 12.

In the course of digestion of fresh solids, putrefactive odors usually develop after most of the soluble carbohydrates have disappeared. When the fresh solids are adjusted these odors are much less, and with correct adjustment never appear. The reasons for the production of odors at high pH values are discussed elsewhere in this report (p. 489). The observations on odors alone would indicate that adjustment to the higher pH values would be objectionable in practice; but the fact that such rapid changes occurred in the 8.2 series, and that the 8.8 series showed such poor results, would limit adjustment to below pH 8.2.

Solids.—The data obtained on the percentage of solids present in the different bottles at the time of sampling during the course of the experiment are presented graphically in figure 6. All data represented by these curves were corrected for amounts of lime added. Total solids in the ripe sludge, used for seeding at the beginning of the experiment, were 4.98 per cent., and daily additions contained on an average also about 5 per cent. solids. The samples used were about 1/40 of the total material and during the first week relatively large proportions of the ripe sludge were necessarily withdrawn. If no samples had been taken, the total fresh solids added in the 2 per cent. addition should have equaled the original amount of sludge in 50 days; in the 3.5 per cent. additions, about 30 days; and in the 5 per cent. additions, about 20 days. The withdrawal of some of the ripe sludge during the first few weeks in relatively larger proportions than the added fresh solids, however, decreased these periods somewhat. On the other hand, later on the proportions were reversed, which resulted, especially for the larger additions, in slightly longer periods. For convenience the periods of 50, 30, and 20 days will be used as a basis of discussion.

If the rate of digestion (reduction in solids) in the different bottles was equal to the rate of addition of fresh solids, the results when plotted should give approximately a straight line. If, however, the rate of digestion was faster than the additions of fresh solids, e. g., if more solids could have been added without impairing digestion, the curves should show a downward trend. On the other hand, when the rate of digestion was less than could be taken care of by the seeded material, the total solids should increase. Figure 6 shows what happened. In the pH 7.2 series the curves for the 2 per cent. additions show a persistent and rapid downward trend for the first 50 days, corresponding to the 50 days calculated to be sufficient for seeding. For the next 30 days the curve is level, showing that the material in the bottle was able to take care of the fresh solids additions, as exemplified by the next 30 days when the curve again dropped slightly. In spite of the fact that the original material, ripe sludge, contained 5 per cent. solids, the total solids figures show a reduction from 5 to 3.7 per cent. The curve for 3.5 per cent. fresh solids addition in the pH 7.2 series shows a rapid decline for the first 45 days, followed by a slight rise, but again followed by a rapid decrease, resulting in a total reduction from 5 to 3.4 per cent. Obviously the amount of ripe sludge was able to take care of 3.5 per cent. fresh solids daily if adjusted to these pH values. The curve for the daily addition of 5 per cent. solids shows a decrease from 5 to nearly 4 per cent. during the first month. However, this was followed by a marked rise, but again followed by a sharp drop during the last period of the experiment. This would tend to show that with careful manipulation it is possible to add 5 per cent. fresh solids daily for some time with comparatively good results. The fluctuations tend to show, especially if it is kept in mind that these experiments were conducted at an even temperature of about 70° F., that in ordinary plant operation, troubles might result. It seems possible, however, that during the season when temperatures in the digestion compartment are above 65° F. tanks could handle 5 per cent. fresh solids daily if adjusted to a pH of 7.2.

The picture presented for the pH 7.6 series is in general the same as discussed above, although the decrease in per cent. solids during the first period of the experiment was less rapid than for the pH 7.2 series. Here, attention must be called to the fact that a lesser decrease in per cent. solids reduction at this reaction does not necessarily mean a less rapid digestion. In a former report (17) attention

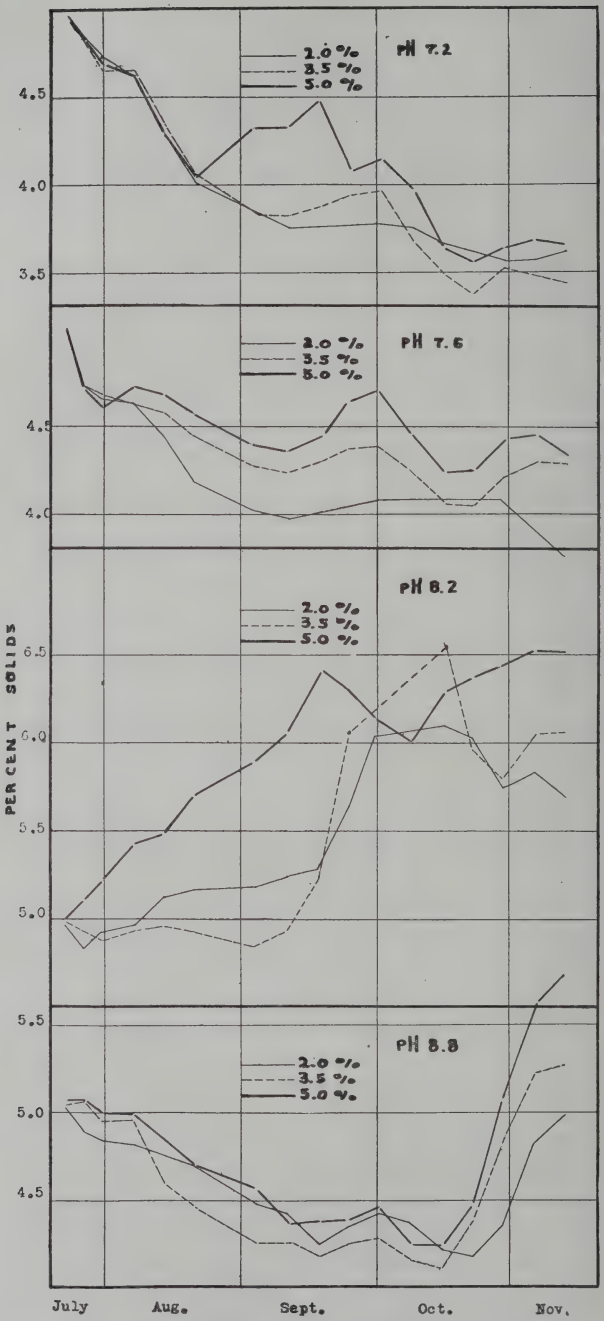


Fig. 6. Solids in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values (Corrected for Lime Added)

was called to the difference in the type of digestion caused by exclusion of air. The statement can now be made that the reaction of the medium is also closely related to the type of digestion. With a certain reaction, apparent "liquefaction" takes place most rapidly, whereas with another reaction "gasification" or "mineralization" overbalances "liquefaction." This question will be discussed at length and data presented in a forthcoming publication.

An examination of the curves for the pH 8.2 series shows an entirely different picture. With additions of 2 and 3.5 per cent. solids no reduction took place during the first 2 months. From then on a rapid increase occurred. A word must be said here about the daily additions of fresh solids. On September 20 the Riensch Wurl screens had to be taken out of operation for cleaning and repairs and were put back into operation October 29. For this reason, the solids collected in the preliminary sedimentation tank were somewhat coarser and heavier. As it was thought best not to alter or dilute these fresh solids, they increased somewhat in concentration. Since the same amounts of solids were added to all bottles, the individual bottle contents in the experiment are entirely comparable. The increase in solids concentration during this period explains why it was possible that the solids content of the bottles could actually increase over the original when digestion was not progressing satisfactorily. In the bottles where an actual decrease of solids took place over the original, digestion can be regarded as better than the curves would indicate.

Under the discussion about odors emanating from the bottles, it was stated that after about one month odors developed in the bottle with 2 per cent. additions, followed shortly by the bottle with 3.5 per cent. additions.

The odors, particularly in the bottles to which 3.5 and 5 per cent. solids were added daily and which were adjusted to pH values of 8.2, were so intensive that under ordinary plant operation handling of material at this pH value would be out of the question unless precautions were taken to seal the tanks, galleries, etc., completely and to burn the gases. The curve shows that the solids, in the bottles with the 2 per cent. addition with this particular reaction, increased but slightly during the first 50 days; with 3.5 per cent. additions it remained practically constant for 40 days; but increased steadily with 5 per cent. additions. The 2 and 3.5 per cent. additions caused a rapid rise in percentage solids after these initial periods, followed by a drop. It would seem, therefore, that the limit of daily additions at a reaction of pH 8.2 is below 2 per cent.

In the discussion of hydrogen-ion concentration of the bottle contents, attention was drawn to the remarkable uniformity of pH values in the 8.8 series. For approximately 90 days the percentage solids decreased somewhat in all bottles of this series. The decrease was persistent and it seemed that good results could be expected at this high pH value. No odors were present during this time. During the next month, however, solids increased rapidly and the stench

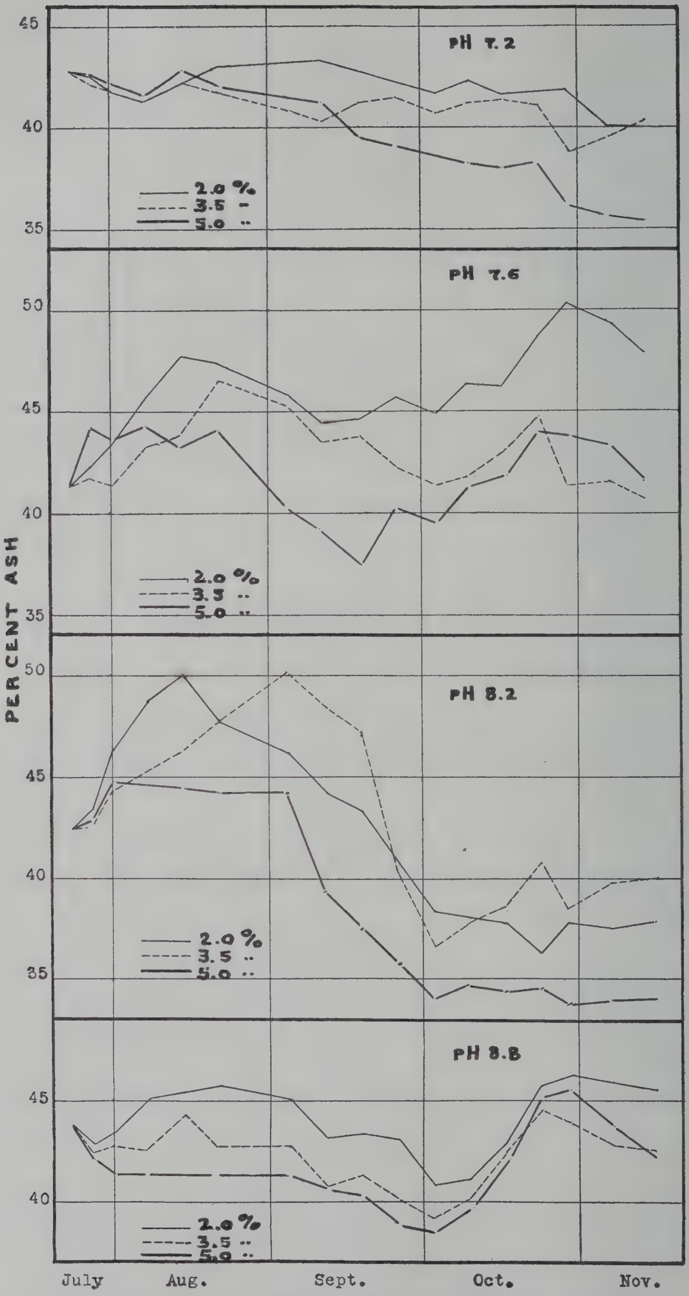


Fig. 7. Ash in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values (Corrected for Lime Added)

emanating from the bottles became unbearable. The comparatively large volume of ripe sludge present at the beginning of the experiment contained a well-balanced flora and fauna. The lime added retarded the action of the organisms responsible for the attack on certain components of the fresh material sufficiently to deter their active decomposition. With very large quantities of lime the activity of all organisms would be inhibited. The amounts of lime added in these cases were sufficient to retard certain groups of organisms, but not enough to sterilize. The result was that when finally these organisms were capable of attack on a larger scale, the action became violent and was accompanied by strong odors. If an analogy might be drawn, the action in the bottles during the first 3 months was similar to experiments made in our laboratory and elsewhere, where insufficient lime had been added for the dewatering of fresh solids. At first the material dries somewhat, but the odors later on indicate that the material was by no means sterile. (See also the discussion on theory of action of lime.)

Ash.—If all organic matter is mineralized at the rate at which additions are made and if samples are drawn equal to the amount of material added, the ash content should remain practically the same. If the rate of mineralization is slower than the rate of additions, ash content should decrease, whereas, if the rate of mineralization is more rapid than the rate of addition, the ash content should increase. In case the percentage solids decreases with constant additions of fresh material and these solids (organic matter) are mineralized, we must find a corresponding increase in ash content. A comparison of figure 7, showing the percentage ash of the different materials, with figure 6, representing the percentage solids, shows that the curves for the bottle contents kept at a reaction of pH 7.2 do not bear this out. Solids decreased with the 2 per cent. addition from 4.98 to 3.61 or about 27 per cent., while the ash content, instead of increasing, remained nearly constant. In case of the 5 per cent. additions, the solids decreased about 26 per cent. and the ash actually decreased nearly 18 per cent. The reasons for these discrepancies are given under the discussion of results.

The curves for ash content of the 7.6 series show a different trend. Daily additions of 2 per cent. showed an initial ash increase corresponding to the decrease in solids. Fluctuations took place in the course of the experiment but near the end of the experiment the percentage solids reduction was about equal to the percentage solids increase, namely 24 and 22 per cent. respectively. Calculations for different points in the curves indicate this definite trend, although sometimes the percentage of ash increase was not so rapid as the percentage of solids decrease. The curves for the 5 per cent. daily addition in this series show that not all material could be mineralized as rapidly as the solids were reduced. At the end of the experiment solids had decreased somewhat with practically no increase in ash. This shows that, although the rate of reduction of fresh solids was faster than the rate of addition, indicating that at this

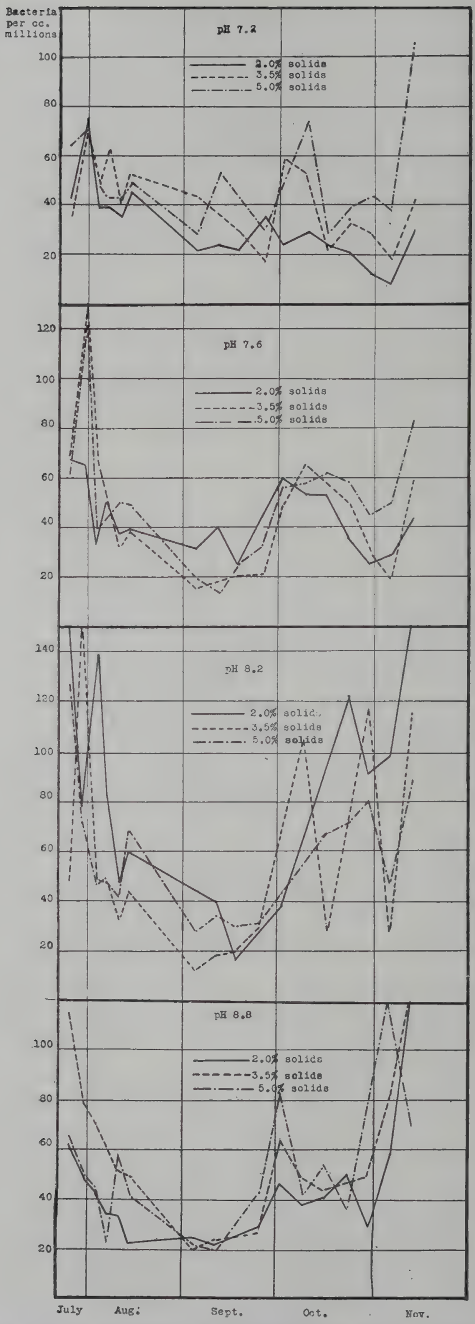


Fig. 8. Bacteria (Plate Counts) in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values

reaction 5 per cent. solids can be handled, the liquefied solids were not mineralized fast enough to prevent a relative decrease in ash. This might mean that in the long run daily additions of 5 per cent. are detrimental to uniform and efficient digestion.

A comparison of the ash and solids curves in the pH 8.2 series tells an entirely different story. At the beginning of the experiment the ash content for the 2 and 3.5 per cent. additions increased rapidly whereas the solids remained constant. This period lasted for not more than 30 days and solids increased rapidly, whereas the ash content dropped markedly, indicating that a piling up of fresh solids took place. The discussion under "solids" of the pH 8.8 series holds for the percentage of ash as well.

Bacteriological

The total numbers of bacteria as revealed by plate counts were determined in an effort to ascertain the influence on the bacterial flora of the addition of lime to digesting material.

The bottles kept at a pH value of 7.2 with various percentage additions of fresh solids, maintained a relatively uniform level throughout the period. They showed a period of initial stimulation followed by a period of decreasing numbers and then finally a second peak (fig. 8). The bottle which received 2 per cent. fresh solids daily did not have a clear-cut secondary peak, but instead the curve shows a continually decreasing trend. The curves for the 3.5 per cent. and 5.0 per cent. fresh solids addition on the other hand are more irregular and have a higher average. The bottle with 5.0 per cent. fresh solids addition shows a decided increase at the end of the experiment. In this series of pH values it was not necessary to add lime to adjust the reaction of the digesting material, but lime was added to the fresh solids to bring the reaction up to the desired value. Under these conditions it could not be expected that there would be a very marked stimulating effect on the numbers of bacteria. The fluctuations recorded are similar to those observed during normal digestion. The outstanding difference between these results and those obtained from a previous experiment on the effect of addition of different amounts of fresh solids to ripe sludge, without any attempt to maintain the reaction, is in the absence of any indication of initial stimulation of bacterial numbers in the experiment under discussion. This is what would be expected if the stimulation of bacterial numbers obtained on adjusting the reaction is due to lime. With this exception the remainder of the curves for the two experiments are identical, inasfar as they both show a secondary stimulation. This conforms to the fact, as will be pointed out later, that this secondary peak is quite independent of the influence of lime and may be due to an internal factor of digestion at this stage.

The series of bottles kept at pH 7.6 gives a picture similar to the ones kept at 7.2 except that the different stages are more prominent and more easily distinguishable. As before, there is a period of

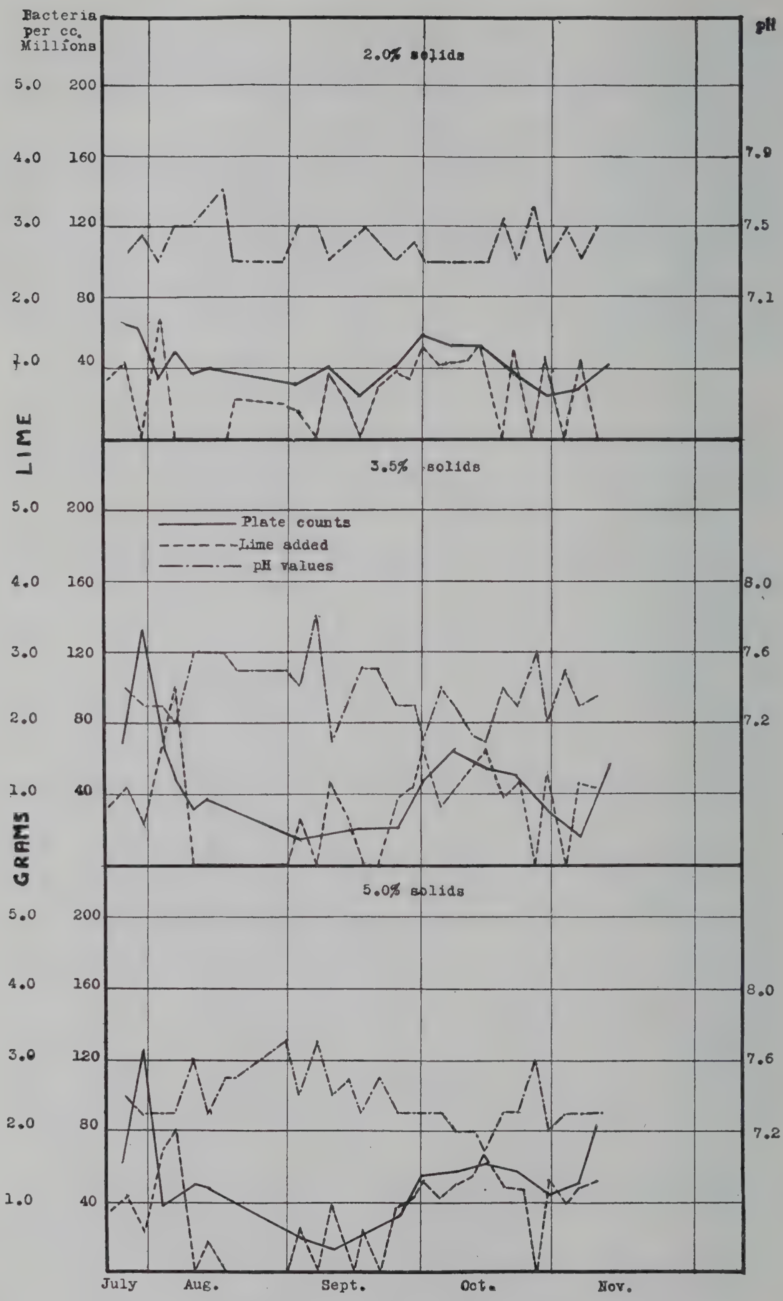


Fig. 9. Comparison of Bacteria (Plate Counts), pH Value Fluctuations and Amounts of Lime Necessary to Maintain the Reaction of the Mixture of Ripe Sludge with Different Amounts of Fresh Solids Added Daily at a pH Value of 7.6

initial stimulation, then a period of relatively low level followed by a secondary peak of lower magnitude but of longer duration than the initial one. The curves for the bacteria present in the bottles with the different amounts of fresh solids added are remarkably similar, with the exception that the smallest addition did not show such a marked initial stimulation as the other two. All three of them, on the other hand, have a similar low level of about the same duration and a second peak taking place at about the same time and of about the same height. These bacterial fluctuations seem to be correlated with the lime added to adjust the reaction of the digesting material, for unlike the previous series, small amounts of lime were necessary from time to time to maintain the pH value at 7.6. Figure 9 shows that the addition of lime to maintain the pH value at a constant level resolves itself also into 3 stages; first, about 2 weeks in the beginning when considerable amounts of lime were necessary, second, a period lasting for about 3 weeks when no lime was added, and then finally the last stage when increasing amounts of lime were necessary to maintain the reaction. In spite of the increasing amounts of lime added, the pH values were not constantly maintained at the desired point. In the initial period the maximum amount of lime addition necessary, came after the maximum stimulation of bacterial numbers, and it is worthy of notice that with decreasing bacterial numbers increasing amounts of lime were necessary. This indicates that the small amounts of lime added, initially stimulated a group of organisms for a brief period, after which they declined in numbers in spite of increasing lime applications. It would seem as if this group belonged to the intestinal type of bacteria which were added with the fresh solids. The fact that with 2 per cent. additions this bacterial peak does not materialize although it does with the additions of 3.5 and 5 per cent fresh solids daily, points the way to this conclusion. This group of organisms does not remain stimulated, but, as without the addition of lime, their numbers are eventually materially reduced. These organisms utilize available carbohydrates and other easily attacked materials and produce large amounts of acids which cannot be neutralized with even increasing amounts of lime. Once this initial stage is over (when these organisms have fulfilled their role) the total numbers decrease and remain at a low level with the subsequent result that the pH values are maintained without the addition of lime. This is the period of readjustment in which the acids produced are being further destroyed or neutralized so that the flora which is to carry on the digestion further to completion can start its activity. In this period the more complex materials are being liquefied or broken down, preliminary to final digestion. Finally the pH value begins to drop and lime becomes necessary in increasing amounts. The curve for the total numbers of bacteria follows closely that of lime. It is well to add that the increase in the bacterial numbers in this case is due to a different group than that at first, and that lime is not the cause but the result of this peak in bacterial numbers as in the initial stage. From the above discussion it would seem that digestion is proceeding in a desirably uniform course in this series, as is

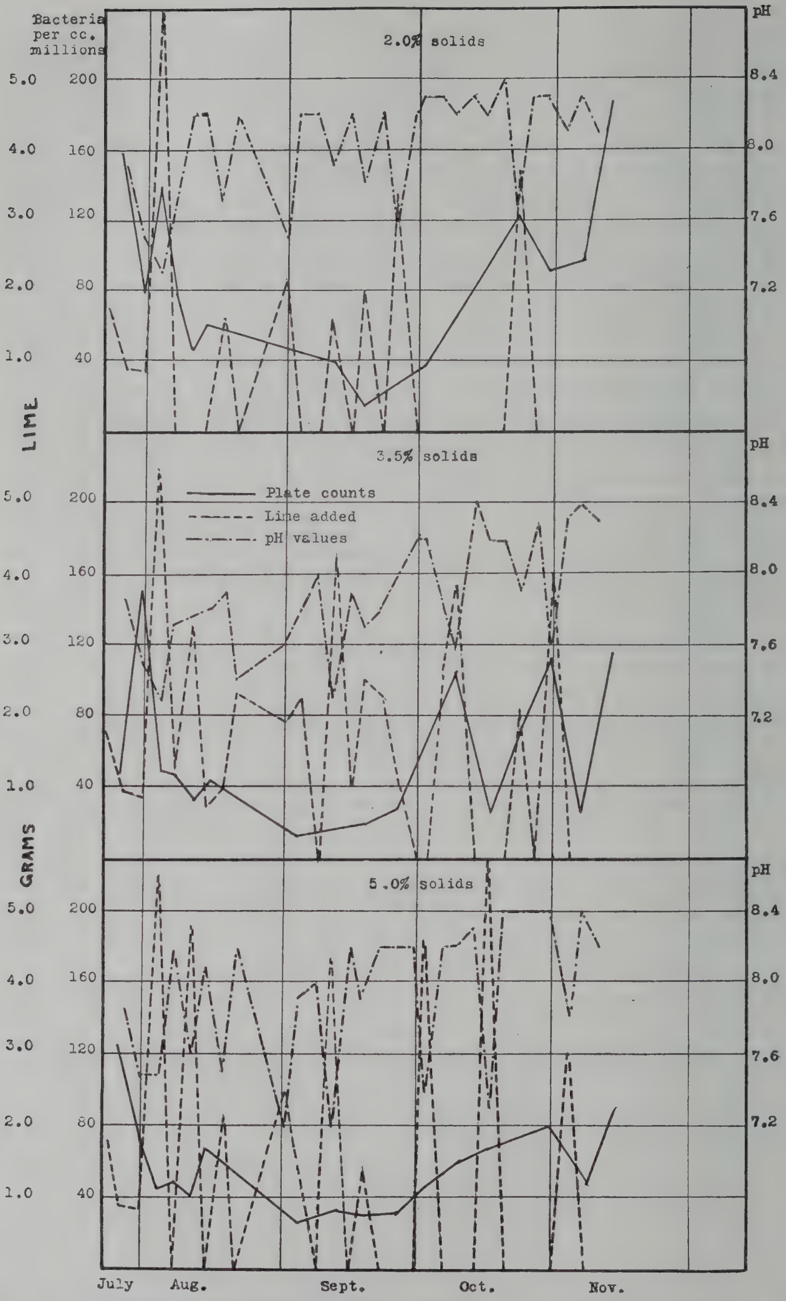


Fig. 10. Comparison of Bacteria (Plate Counts), pH Values, and Amounts of Lime Necessary to Maintain the Reaction of the Mixture of Ripe Sludge with Different Amounts of Fresh Solids Added Daily at a pH Value of 8.2

indicated by the normal average cycle, without the large and erratic fluctuation in the bacterial curves. It would further seem that even with a 5 per cent. addition of solids the equilibrium is not so materially upset that unstable conditions prevail, which would have been the case if the reaction had not been adjusted.

In passing to the next series of bottles kept at pH values of 8.2 we have a picture similar in its gross outline to the previous ones (fig. 10). The three stages in the bacterial curves as observed before are still discernible with the exception that the initial and final peaks are much more pronounced and the fluctuations greater. To maintain the pH value greater amounts of lime than in the previous cases were necessary during all stages, hence, there were greater bacterial numbers in general. After the initial stimulation of bacteria with comparatively small amounts of lime, the numbers decreased, whereas at the same time more lime was necessary to maintain the pH at 8.2. This sequence in the peaks of bacteria and in lime curves is the same kind of relationship observed before, but the period in which no lime was necessary to maintain the reaction in the previous series has been either wiped out or greatly curtailed. So in this case, with even a low level of bacterial population, considerable amounts of lime were needed to maintain the reaction. The greater the percentage of fresh solids added, the greater was the instability of the pH curve; and the more lime required to maintain the pH values, the lower was the bacterial curve. Here, with the greater amounts of fresh solids, the lime necessary to maintain the reaction already shows an inhibitory action on the bacteria. When the bacteria were at a low level and comparatively large amounts of lime were necessary to maintain the pH values, a group of bacteria must have been active to a certain extent in producing acids but their numbers were either not large enough to be reflected in the total counts or did not grow on the ordinary plates. The latter of the possibilities seems to be more acceptable in view of the fact, as will be demonstrated later, that lime stimulates the activities of spore-forming anaerobes that are capable of producing large amounts of gas and also of producing quantities of acids, but which do not grow readily on ordinary plates. It is also probable that lime stimulates other groups of bacteria as well with the result that vast fluctuations occur after the proper equilibrium is upset.

The above discussion indicates that at this pH value a critical point is reached whereby the normal equilibrium is upset, subsequently resulting in a series of unstable fluctuations in the bacterial population. The picture in this series is quite different in this respect from the preceding or from the series next to be considered.

Although the curves in the series of bottles which was maintained at a pH value of 8.8 (fig. 11) can still be split up into 3 well defined sections the initial stimulation instead of being higher than that of pH 8.2 is actually lower. The period of retardation following it is longer and more pronounced as indicated by a low bacterial level and by the fact that pH values were maintained for

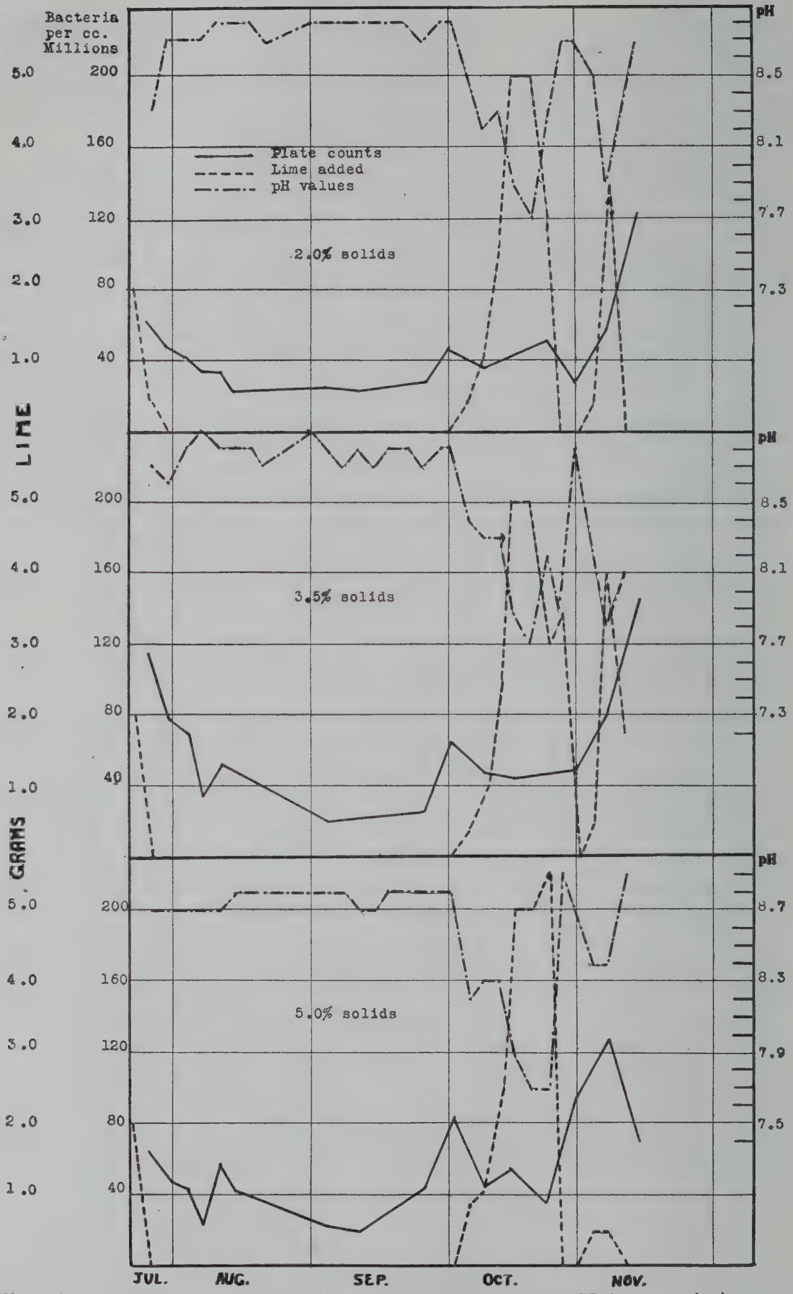


Fig. 11. Comparison of Bacteria (Plate Counts), pH Values, and Amounts of Lime Necessary to Maintain at a pH Value of 8.8 the Reaction of the Mixture of Ripe Sludge with Different Amounts of Fresh Solids Added Daily

a long time without the addition of lime. Whereas in the previous series, the pH was dropping intermittently throughout the experiment in spite of the addition of large amounts of lime, in this case the pH value did not change for over two months even without the addition of lime. At the end of this period, activity started explosively, pH values dropped precipitously and in spite of enormous amounts of lime added it could not be constantly maintained. Bacterial numbers were kept down during this period by excessive amounts of lime added at the beginning, and the stimulation took place only after the retarding effects of initial lime were overcome and digestion was well under way. As before the curves for the three different percentage additions had materially the same trend.

Some interesting facts are borne out from the average numbers of bacteria for the whole period in different bottles as given in table 1.

TABLE 1

Average numbers of bacteria on wet and dry basis and the amounts of lime added to the digesting material during the whole period.

	pH 7.2			pH 7.6		
	BACTERIA			BACTERIA		
SOLIDS	per cc.	per gram.	Lime added	per cc.	per gram.	Lime added
per cent.	*millions*	*millions*	*gm.*	*millions*	*millions*	*gm.*
2.0	30.6	1268	0	42.7	1704	16.0
3.5	40.4	1697	0	48.2	1823	21.0
5.0	44.5	1990	0	51.2	1938	22.0
	pH 8.2			pH 8.8		
2.0	79.8	2372	21.0	44.0	1568	21.0
3.5	56.5	1582	41.0	59.9	2029	26.0
5.0	57.9	1758	35.0	48.1	1849	21.0

In general for a given pH value the average bacterial numbers are higher with the large additions of fresh solids but, as had been brought out in a previous publication (17), this is in no way proportional to the increase in organic matter. This generalization does not hold strictly, however, in the case of higher pH values. At a pH value of 8.2 with a 2 per cent. fresh solid addition higher average numbers were obtained than with either 3.5 per cent or 5 per cent. The explanation for this has been given before; namely, that with larger quantities of fresh solids the instability of the pH curve was greater and more lime, which had an inhibitory effect on the bacterial numbers, was required to maintain the pH. Whereas 21 gm. of lime was necessary to maintain the pH during the whole period at 8.2 for 2 per cent. concentration, 41 and 35 gm. were added to bottles receiving 3.5 and 5.0 per cent. solids respectively. In fact the highest average numbers of bacteria occurred at a pH value of 8.2 for all additions of fresh solids. But this, as pointed out before, can not be taken as a desirable phenomenon as it was accompanied by great fluctuations, indicating a condition of instability.

In passing over to the pH range of 8.8 the average total numbers of bacteria already indicate a dropping off over the previous series except with the 3.5 per cent. solids addition, which is only slightly higher than the same percentage addition of the previous series. Even though the total lime added to this series is not higher than in the previous case, the initial amounts of lime added to the ripe sludge checked activity to such an extent that bacterial numbers were repressed and lime additions were not necessary for considerable time.

It is interesting to note that these same relationships hold whether the bacterial numbers are calculated on a wet or dry basis. None of the above statements in regard to the effect of the different additions of fresh solids needs to be modified when the bacteria are presented on the dry basis. This is remarkable in view of the fact that the concentration of the solids in the different bottles varied within a wide range (1.5 to 6 per cent. organic matter). This would indicate that neither the concentration of the material nor the percentage of organic material has as marked an influence on the bacterial numbers as certain internal factors connected with the course of digestion or as a change in the environmental condition brought about by lime. This is in line with other observations which show that it is not so much the total concentration of solids as the type of food material that affects the numbers of bacteria.

In general, lime additions, up to a certain point, stimulate the numbers of bacteria, but maximum numbers do not necessarily mean maximum digestion. The numbers of bacteria are also increased by larger additions of solids but not to so great an extent as in the case of lime. With the increase of the total numbers of bacteria at higher pH values, great fluctuations in numbers occur, indicating a condition of instability. In fact larger additions of fresh solids in conjunction with higher pH values may bring about such unstable conditions that the increased amounts of lime necessary cause a depression in numbers of bacteria. In view of these facts the adjustment of the material to a pH value of 7.6 is most desirable since it gives high bacterial numbers and at the same time a uniformly smooth curve.

In conclusion it can be said that lime in small quantities (sufficient to neutralize the initial potential acidity) does not stimulate the bacteria. Stimulation takes place in this case only as a result of internal factors, namely, the decomposition of available carbohydrates in the initial stages by the intestinal group and a secondary stimulation due to the flora that becomes established and carries on the digestion proper. (See series pH 7.2 and 7.6.) With larger amounts of lime than is necessary for the neutralization of the initial potential acidity, a marked stimulation of bacteria takes place over the normal stimulation due to internal factors. This condition presumably prevailed between pH 7.6 and 8.2 because already at pH 8.2 an unstable condition has been reached resulting in great fluctuations in bacterial numbers. With still larger quantities of lime a marked retardation is evidenced.

Zoological

The protozoa, in the series of bottles adjusted to a pH value of 7.2 were numerically fairly constant. As indicated by the curves of figure 12 no great fluctuations appeared. The flagellates were the

TABLE 2

Weekly average of protozoa found in the four series of bottles (per one cubic centimeter)

GENERA	FRESH SOLIDS ADDED					
	SERIES pH 7.2			SERIES pH 7.6		
	2.0%	3.5%	5.0%	2.0%	3.5%	5.0%
Trepomonas	20	305	145	314	95	423
Tetramitus	400	1427	454	145	282	127
Monas	120	1040	1737	286	773	818
Bodo	100	145	243	41	328	155
Cercomonas	150	791	260	....	172	250
Cercobodo	220	55	....	86	118	364
Euglena	70	36	....	....	....	....
Pleuromonas	....	....	....	....	....	....
Mastigamoeba	20	127	245	80	213	118
Dinomonas	....	....	....	....	....	....
S. Flagellates	2000	2400	3500	1418	3459	3682
Holophrya	70	277	475	136	....	491
Hexotricha	220	41	54	90	23	159
Trimyema	100	304	1150	168	323	272
Colpoda	50	111	464	....	477	....
Metopus	4	140	314	36	150	231
Chilodon	....	99	....	....	....	....
Vorticella	....	....	....	50	....	....
Amoebae	....	60	....	....	122	....
*Total	3.54	7.3	9.0	2.8	6.5	7.0

* Total protozoa in thousands per cubic centimeter.

GENERA	FRESH SOLIDS ADDED					
	SERIES pH 8.2			SERIES pH 8.8		
	2.0%	3.5%	5.0%	2.0%	3.5%	5.0%
Trepomonas	186	....	145	....	2900	50
Tetramitus	23	323	236	723	4818	1173
Monas	109	145	682	141	527	....
Bodo	295	241	200	....	1115	273
Cercomonas	22	95	95	241	1541	459
Cercobodo	45	245	1223	....	43	545
Euglena	....	....	....	....	....	....
Pleuromonas	....	59	....	....	....	....
Mastigamoeba	72	....	....	....	50	50
Dinomonas	....	....	....	....	....	50
S. Flagellates	677	1168	4377	1718	18191	40841
Holophrya	467	....	491	36	159	236
Hexotricha	....	....	....	....	50	50
Trimyema	100	64	100	28	223	28
Colpoda	....	59	....	....	....	....
Metopus	....	....	....	....	....	....
Chilodon	....	....	....	....	....	....
Vorticella	....	....	....	18	....	....
Amoebae	....	36	36	....	....	18
*Total	2.0	2.4	7.5	2.9	29.5	54.0

* Total protozoa in thousands per cubic centimeter.

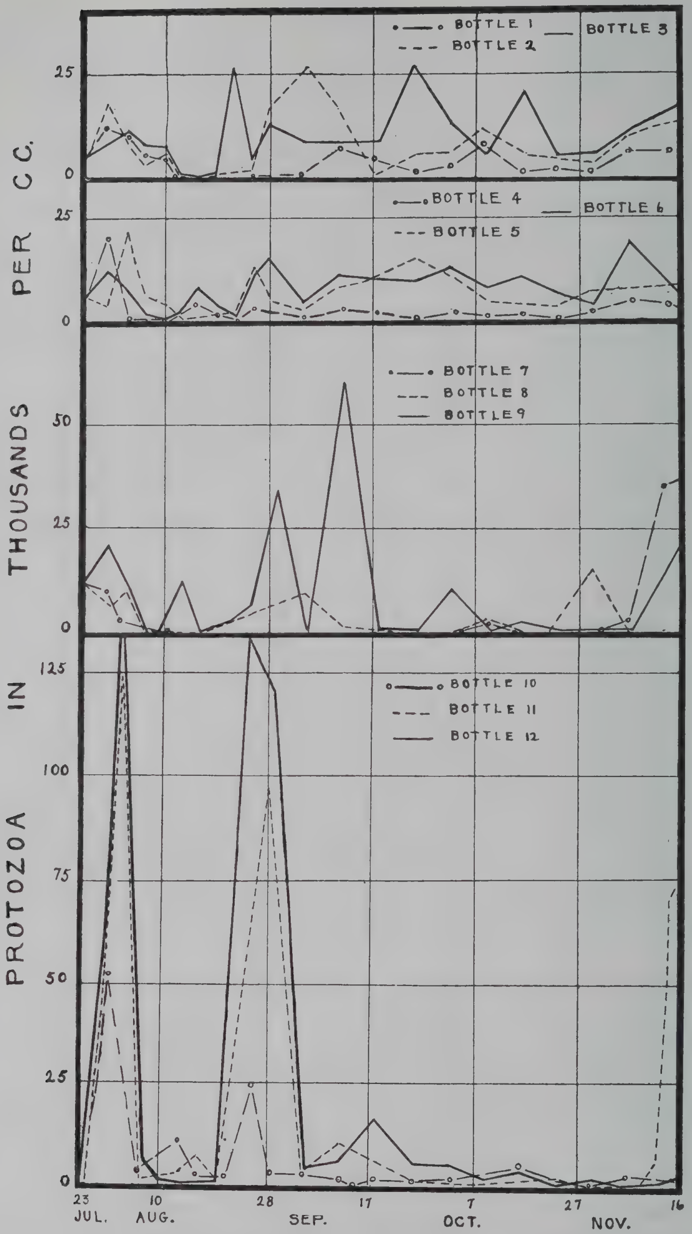


Fig. 12. Protozoa in Mixtures of Ripe Sludge with Different Amounts of Fresh Solids Added Daily and Maintained at Definite pH Values

most abundant, and belonged to the species that predominate in the Imhoff tanks. Table 2 indicates the genera which were present.

The numbers of protozoa, in the bottles of series pH 7.2, increased proportionately to the amount of fresh solids added. Compared with the 2 per cent. additions of fresh solids, the 3.5 per cent. addition almost doubled the number of protozoa, and the 5 per cent. addition increased the protozoa approximately 2.5 times. The bacteria, as already pointed out in the bacteriological discussion, increased in numbers with the addition of larger amounts of fresh solids. The proportionate increase, however, was greater among the protozoa than among the bacteria.

The series of bottles adjusted to a pH value of 7.6 contained an average of one thousand less protozoa per cubic centimeter than the series having a pH value of 7.2.

The reduction in numbers of protozoa is undoubtedly due to the amount of lime which had to be added to increase the alkalinity from 7.2 to 7.6. Laboratory experiments have shown that lime has a lethal effect upon protozoa in a one part to one thousand parts concentration (17).

The bottle contents adjusted to a pH value of 8.2 were very unstable in regard to their protozoan population. The bottle receiving 2 per cent. of fresh solids contained no protozoa from August 7 to October 30, 1925. This bottle was apparently chemically unsuited for protozoan life. The protozoa, in the bottles receiving 3.5 per cent. and 5 per cent. fresh solids, appeared and disappeared sporadically. The data indicate that they disappeared after each addition of lime. If the lime itself was not lethal, the sudden rise in reaction may have been the cause. The protozoa were probably unable to adjust themselves physiologically to the sudden rise in the pH value. This may be of interest in cases where acid or alkaline trade wastes are dumped into sewers.

The figures in table 3 indicate the behavior of the protozoa after the addition of lime.

TABLE 3

Behavior of protozoa and numbers when lime is added

Date	Initial pH	Protozoa thousands per cubic centimeter	Lime added gm.	Adjusted pH	Protozoa thousands per cubic centimeter
8/11/25	7.6	11.9	4.81	8.1	0
8/21/25	7.4	2.0	2.30	8.1	0
9/11/25	7.3	1.6	4.27	8.1	0
10/2/25	7.6	2.0	2.60	8.2	0
10/6/25	7.3	0.4	6.00	8.3	0
10/30/25	7.6	14.6	4.00	8.3	0

In the series kept at pH values of 8.8, lime was added to the ripe sludge when the experiment was started, in order to adjust the pH value as desired. The hydrogen-ion concentration remained constant without more additions of lime from July 27 to October 2, 1925. During this period the protozoa were numerous but fluctuated greatly as shown in figure 12. The fluctuations in the bottles receiving 2 per cent. fresh solids varied in numbers from zero to 53,000 per cubic centimeter. The bottle receiving 3.5 per cent. varied from zero protozoa to 330,000 per cubic centimeter, and the bottle having 5 per cent. of fresh solids added, varied between zero and 824,000 protozoa per cubic centimeter. It is of interest to refer to previous findings, in regard to protozoan numbers, when digestion is unsatisfactory. When tank contents are slightly below the neutral point protozoa increase rapidly. This same phenomenon occurred at this high pH value. Since most of these organisms live on intermediate decomposition products, the statements made under the chemical and bacteriological discussion regarding retardation of certain groups of bacteria are here emphasized because the protozoa increase when the bacteriological equilibrium is unbalanced. The species of protozoa present were the same as found in the different series having lower pH values.

In the latter part of the experiment lime was required every week in order to adjust the pH value to 8.8. At this time few or no protozoa were present.

Some results of the present experiment which were true for all four series studied were : 1. The range of pH values between 7.0 and 8.8 had no selective effect upon the kind of species of protozoa found; 2. The protozoa increased approximately in proportion to the amount of fresh solids added; 3. The addition of lime restricted the number of protozoa.

The same species of protozoa were present in all the bottles of this experiment, 18 genera being enumerated. As indicated in table 2 the flagellates were the most abundant. The dominant species were *Trepmonas agilis, Tetramitus pyriformis, Cercomonas sp., Euglena gracilis,* and several species of *Bodo* and *Monas.* Aside from these named, there were exceedingly minute flagellates which were left unclassified. The ciliates were far less numerous. The genera were *Holophrya, Trimyema, Colpoda, Metopus,* and *Hexotricha.* A few amoebae (mostly *Hartmanella hyalina*) and mastigamoebae were found.

The present experiment exhibits strikingly the relationship that exists between the number of protozoa and the amount of incoming fresh solids. The figures in table 4 give a summary of the results for all the different series.

TABLE 4

Average number of protozoa present at different reactions and different percentages fresh solids additions

	FRESH SOLIDS ADDED		
REACTION	2%	3.5%	5%
pH			
7.2	3.5*	7.3	9.1
7.6	2.8	6.5	7.1
8.2	2.0	2.5	7.6
8.8	2.9	29.5	54.1

*Protozoa in thousands per cubic centimeter.

The protozoa increased with larger additions of fresh solids (wet basis) as is the case with the numbers of bacteria, but calculated per gram of dry solids the bacteria decrease with larger quantities of fresh solids whereas the protozoan numbers remain constant, except when large amounts of lime are added (bottles 11 and 12). In these two bottles the protozoa were four and five times more numerous.

In general the bottles receiving 2 per cent. fresh solids daily had the largest quantities of ash at the end of the experiment. Bottle 4, adjusted to a pH value of 7.6 and receiving 2 per cent. fresh solids contained the highest percentage of ash, but the contents of this bottle as indicated both in figure 12 and table 2 contained few protozoa and no high fluctuations of protozoa. Bottle 9, having a fluctuating protozoan fauna and receiving 5 per cent. of fresh solids had a low percentage of ash. The protozoa in this bottle were killed after each addition of lime. They appeared sporadically between the lime additions. The constant addition of lime reduced the protozoa to such an extent that the indicated average number during the experiment became very low. The high average numbers of protozoa in bottle 12 (pH 8.8 with 5 per cent. fresh solids additions) are caused by the large fluctuations in numbers during the time that no lime was added. Bacterial activities in this bottle were apparently retarded (see bacteriological discussion) during this period.

TABLE 5

Relation between protozoa and bacteria and ash content

(Protozoa and bacteria per gram dry solids)

Bottle Number	Solids Additions	Reaction	Protozoa	Bacteria	Ash*
	Per cent.	*pH*	*Thousands*	*Millions*	*Per cent.*
1	2.0	7.2	1.8	15.3	40.0
2	3.5	7.2	2.1	11.6	40.3
3	5.0	7.2	1.8	8.9	35.4
4	2.0	7.6	1.4	21.3	48.9
5	3.5	7.6	1.8	13.7	40.8
6	5.0	7.6	1.4	10.2	41.7
7	2.0	8.2	1.0	39.9	37.9
8	3.5	8.2	0.7	16.1	40.0
9	5.0	8.2	1.5	9.6	34.0
10	2.0	8.8	1.5	11.0	45.5
11	3.5	8.8	8.4	17.1	42.9
12	5.0	8.8	10.8	9.6	42.0

*Corrected for lime added.

Table 5 shows the relation between the average number of protozoa and bacteria present and the percentage of ash at the end of the experiment. The protozoa and bacteria are calculated per gram of dry solids. It will be noticed that protozoa were practically constant, except in bottle 12, whereas the bacteria fluctuated with the percentage of fresh solids additions. It seems, therefore, that the protozoa are not directly responsible for the increase or decrease in ash content.

The present investigations confirm conclusions which have been derived in previous experiments and data collected on operating Imhoff tanks during four years; viz., that the number of protozoa and their amount of fluctuation are criteria which indicate whether digestion is proceeding favorably. Lackey (17) has pointed out that every time foaming occurs and a tank functions poorly the protozoa are present in enormous numbers.

In the series pH 8.8 where digestion was retarded and in the pH 8.2 series with undesirable digestion the protozoa were fluctuating irregularly in large numbers. The series pH 7.3 and 7.6, which were able to take care of the fresh solids additions, had no enormous numbers nor great fluctuations of protozoa.

Where the percentage of fresh solids was increased the proportionate increase of protozoa was greater than the proportionate increase of bacteria. The increase of protozoa consisted mostly of flagellates which were sapropelic in their mode of nutrition and apparently lived on substances present in dissolved form, such as partially broken down organic material. It appears that where the bacterial flora is such as to hasten decomposition, these partially decomposed substances do not accumulate and the protozoa do not find a favorable nutritive medium. Therefore, where digestion proceeds rapidly as in properly functioning digestion tanks the protozoa do not ascend to hundred thousands per cubic centimeter.

Discussion

In a former annual report (17) it was pointed out that under certain conditions (absence of air) the solid organic materials were transformed to liquid organic materials, which were fairly stable and could be disposed of by ordinary drying. Only if similar "liquefaction" can be induced by a change of reaction can the discrepancies pointed out above, regarding the decrease of solids without a corresponding increase in ash at certain reactions, be explained. A comparison of the curve for ash and solids content of the 2 per cent. solids addition at a pH value of 7.6 (fig. 6 and 7) shows that the ash content increased more nearly in ratio to the percentage solids decrease. The first part of the curves for material (2 and 3.5 per cent. additions) kept at pH values of 8.2 shows a rapid rise in ash content, whereas the solids remained constant, but the percentage ash dropped rapidly when the percentage solids increased. It would seem thus that during the first few weeks the sludge present was sufficient not only to take care of the fresh solids, but that mineralization took place. After this initial period the percentage ash decrease was nearly equal to the percentage solids increase. If the contention expounded above is correct that there was retardation of certain groups of bacteria during the first 3 months in the bottles kept at pH values of 8.8 we should find but slight changes in ash content. The curves for this series show this actually to be the case.

Returning now to the question "liquefaction" and "mineralization" or gasification at different reactions, we have indicated that at pH values of 7.2 the processes of digestion are mainly in the direction of liquefaction whereas at pH values of 7.6 "mineralization" becomes more dominant. At pH 8.2 "mineralization" was first most pronounced but was later equalized, so that "liquefaction" took place as rapidly or perhaps more rapidly than "mineralization". The drawback in the latter case was the great fluctuations during the course of digestion. Calculations on the percentage reductions of organic matter and percentage ash increase for the whole period illustrate perhaps even more conclusively and directly these statements. The figures are given in table 6. In case no increase or decrease in the percentage reduction of organic matter were shown it would mean that all additions of fresh solids was taken care of by the original ripe sludge. With an increase in the percentage organic matter not all material was decomposed at the same rate as additions were made. A decrease in the percentage organic matter shows that the rate of decomposition was greater than the rate of additions of fresh solids. In table 6 all three of the pH 7.2 series show a decided decrease in the percentage organic matter over the original. However, the percentage ash also decreased somewhat in numbers 1 and 2 and considerably in number 3, indicating that liquefaction was more rapid than mineralization. The rate of liquefaction was slightly lower in the pH

TABLE 6

Percentage organic matter and ash increase or decrease at the end of the experiment

Bottle No.	1	2	3	4	5	6	7	8	9	10	11	12
Solids added	2%	3.5%	5%	2%	3.5%	5%	2%	3.5%	5%	2%	3.5%	5%
pH	7.2	7.2	7.2	7.6	7.6	7.6	8.2	8.2	8.2	8.8	8.8	8.8
Organic matter at beginning, per cent	2.84	2.84	2.84	2.98	2.98	2.98	3.48	3.48	3.48	2.88	2.88	2.88
Organic matter at end, per cent.	2.08	2.10	2.38	2.33	2.73	2.79	4.14	4.13	4.43	3.13	3.46	3.85
Organic matter, increase or decrease, per cent	—26.7	—26.0	—16.0	—21.7	—8.4	—6.4	+15.9	+15.7	+21.6	+8.0	+16.7	+25.2
Ash at beginning, per cent.	42.9	42.9	42.9	41.3	41.3	41.3	42.6	42.6	42.6	44.0	44.0	44.0
Ash* at end, per cent	40.0	40.3	35.4	48.9	40.8	41.7	37.9	40.0	34.0	45.5	42.9	42.0
Ash* increase or decrease, per cent.	—6.8	—6.0	—17.5	+15.5	—1.0	+0.7	—11.0	—6.0	—20.0	+3.2	—2.5	—4.5

— is decrease.
+ is increase.
* Figures corrected for lime additions.

7.6 series, but mineralization, or percentage ash increase, was nearly equal to the percentage decrease in organic matter. Percentage reduction of organic matter in the pH 8.2 series was negative; there was an actual increase or accumulation in organic matter while the ash decreased. This does not mean that at a pH value of 8.2 liquefaction is greater than mineralization, but rather that liquefaction was delayed or retarded; the percentage increase in organic matter was nearly equal to the percentage decrease in ash. From all evidence presented thus far it seems clear that at pH values of 7.2 liquefaction overbalances mineralization, whereas at pH 7.6 the reverse is true, provided not too much fresh solids are added daily to upset the biological equilibrium.

"Mineralization" employed in the sense of producing stable mineral end products is, as far as biological sewage decomposition is concerned, a misnomer. The term has been used here only to designate processes producing ultimate end products which differ from "liquefaction" or "septicization". Mineralization included not only the production of comparatively stable end products like carbonate and "humus" but gases like CO_2, CH_4, and N_2, as well. "Mineralization", therefore, should be comparable to "gasification" and in cases where the mineralization or gasification overbalances liquefaction, larger volumes of gases should be found. This is precisely the case. At different reactions gas production is different. Results on series of experiments kept at different reactions and different temperatures, show that gas production is directly related to the reaction of the material. Total gas production is not only different at different reactions, but the composition changes also.

It has been stated repeatedly that under ordinary conditions during the summer not more than 2 per cent. fresh solids daily should be added to a tank. What does this mean in required sludge capacity per capita? Calculations show that domestic sewage has a solids content of about 70 gm. (dry solids) per capita per day. There must be present 50 times this amount in the form of ripe sludge, or 3500 gm. (roughly 7.7 pounds of dry solids). Assuming that the sludge contains 95 per cent. moisture, the total weight of the sludge would be 145 pounds or a required volume of 2.34 cubic feet per capita. Ripe sludge, however, usually contains less than 95 per cent. moisture. If it contains 90 per cent. moisture 1.2 cubic feet per capita would be necessary. If 100 days are allowed for the digestion of incoming material, the total amount of per capita effective digestion space (with an average solids content of 5 per cent. 95 per cent. moisture) in the digestion chamber can under these circumstances be not less than 2.6 to 2.7 cubic feet. It must be borne in mind that these calculations are based on the digestion capacity for material treated during the summer.

By controlling the reaction by additions of hydrated lime the amounts of fresh solids to be added can be increased from 2 to 3.5 per cent. daily, or an increase of 75 per cent., and the required per capita sludge capacity in a tank would therefore be under such conditions about 1.4 to 1.5 cubic feet.

Summary

The effect of lime on sludge digestion is pronounced, influencing the flora and fauna and consequently the chemical intermediate and end products. Lime also changes the physico-chemical relation in sewage solids so that the solids are differently distributed in the liquid phase with different amounts of lime or, better, with different reactions. In general, lime additions up to a certain point stimulate the numbers of bacteria, but maximum numbers do not necessarily mean maximum digestion. With higher reactions (above pH 7.6) great fluctuations in bacterial numbers occur, indicating a condition of instability. At these higher reactions (pH 8.2 and 8.8) odors emanating from the digesting material are stronger and more offensive. The numbers of protozoa decrease markedly when the reaction of the digesting material is changed from pH 7.2 to 7.6 and higher reactions cause rapidly alternating increases and decreases, but the variations of pH values between 7.2 and 8.8 have no limiting effect on the variety of species.

"Liquefaction" overbalances "mineralization" (gasification) at pH 7.2, but the reverse is true at reactions of pH 7.6 and above. Most rapid and satisfactory digestion proceeds at pH values of 7.3 to 7.8.

If the reaction of incoming fresh solids is kept at pH 7.3 to 7.6, odors are practically absent.

Daily additions of fresh solids kept at pH values of 7.3 to 7.6 can be increased from 2 to 3.5 per cent. dry solids (on the basis of ripe sludge) and with careful manipulation possibly to 5 per cent., reducing the relation of ripe sludge necessary for efficient digestion from 50 to 1 of fresh solids daily, to 30 to 1, possibly to 20 to 1.

Unadjusted but properly seeded material requires a per capita digestion space (in summer) of not less than 2.6 to 2.7 cubic feet. With reaction control (judicious application of hydrated lime) this per capita effective digestion capacity can be reduced under these conditions to 1.4 to 1.5 cubic feet.

IMHOFF TANKS

Introduction

During the last 3 years extensive studies have been made on operating and resting Imhoff tanks. These studies were continued during the first few months of the fiscal year 1925-26, but were discontinued in the fall of 1925. The main purpose of the investigations on Imhoff tank behavior during the summer of 1925 was to study: first, a comparison of two tanks, one of which had been treated with lime to adjust the reaction of the tank contents and, second, possible after effects of the alterations of a tank described in our fourth annual report (17). The latter part of this study will be reported only incidentally to the main problem, adjustment of reaction. During the period of October, 1925, to April, 1926, particular attention was paid to a separate sludge digestion tank recently built. The results of this study are presented elsewhere in this report. Again during the spring of 1926 some attention was paid to the Imhoff tanks in an effort to control foaming by changing the reaction of the tanks. The latter work was of no great importance since the tanks part of the time were not running as regular Imhoff tanks, but sometimes partly as sedimentation and storage tanks and at other times as Imhoff tanks.

The methods of sampling and analyses and the nomenclature used here have been described in earlier reports (15, 16).

Results

In order to gain some understanding of the behavior of tanks under different conditions the circumstances of operation must be known. As long as tanks are operated for any length of time under certain conditions it is comparatively simple to draw some general conclusions, but when the operation must of necessity be modified at fairly frequent intervals to meet demands of increased load the difficulties become increasingly greater for the interpretation of accumulated data and the drawing of definite conclusions.

The superintendent, Mr. John R. Downes, of the Plainfield Joint Sewage Works, has experienced unusual difficulties during the last year on account of considerable increase in solids to be handled. Eddy (6) reports for Plainfield an average amount of solids of 173 p.p.m.[1]. The plant was designed for 4,000,000 gallons per day dry weather flow at a time when the water was not metered in the different towns tributary to the plant. In spite of the fact that the average flow was but 3.2 million gallons daily during 1925 the amounts of solids increased to an average of 216 p.p.m. or 5763 gallons (95 per cent. moisture) daily. The average amount of solids after May 1 was 220 p.p.m. with a far greater removal than previously. Subsequent to May 1 the settling tank was cleaner because of the removal of sludge in the spring and also because of the removal of some of the solids to the separate sludge digestion tank. The large increase in retained solids was due to a change in manipulation of the tanks as an effort by the superintendent to produce a greatly improved effluent.

From the above brief discussion it can be seen that with a change in manipulation, conditions at a plant can be considerably aggravated or lessened according to the desire or conscientiousness of the operator. A plant, designed for a specific number of gallons of sewage per day, might with a conscientious operator, prove entirely inadequate if no special means were employed to take care of the increased amounts of retained solids; with a careless operator on the other hand, such a plant might be quite adequate, because a large percentage of the solids received pass through the sedimentation chamber and are never treated. If, in addition to a greater removal the total incoming per capita suspended solids increase, still more troubles are in store. Under such conditions it is extremely interesting to compare experimental results obtained during different years and with different treatments of individual tanks.

---

[1] We are indebted to Mr. Downes for the statement of solids collected in the settling compartments of the tanks during 1925, presented in table 7.

TANK 3

Chemical

On June 11, 1925, pumping of partially digested material into a round separate sludge digestion tank was started and continued to July 2. The tank was kept in operation until July 20, rested for a few days, again put into operation for 5 days, and thereafter rested until the end of the experiment on October 15.

Our experiments were begun on July 29 shortly after the removal of partly digested material was stopped. For 18 days the tank was kept in operation and rested thereafter. It is clear, therefore, that for only a short time during the entire length of the experiments, was this tank running as an Imhoff tank and that during August, September, and October it was functioning as a digestion tank without additions of fresh solids. All analyses reported were made on the liquid portions between scum and sludge in the digestion compartment. Figure 13 shows that the hydrogen-ion concentration of the tank contents dropped somewhat during operation, increased slightly during the first resting period, dropped again during the second short period of operation and hovered thereafter around 7.2. The curve for total acidity shows the greatest fluctuations during the periods of alternate resting and operation. Total alkalinity was very low; it increased gradually but remained at a constant low level. Ammonia remained very low during operation and increased gradually with the oscillations always noted during the course of digestion and apparently indicating the breaking down of protein compounds followed by their utilization by microorganisms. A comparison of this curve (fig. 13) with the curves for protozoa (fig. 15) and bacteria (fig. 14) gives evidence of this.

The solids content of the supernatent liquid was high during the period of operation, dropped at once when the tank was shut off, and decreased gradually to about 0.15 per cent. toward the end of the experiment. The percentage ash of the solids in the liquid increased from an average of about 37 per cent. during operation in July to an average of 56 per cent. in October. The ash content of incoming fresh solids at Plainfield fluctuated between 22 and 24 per cent. when this tank was in operation. It seems clear therefore that the solids in the supernatent liquid at the beginning of the experiment were not only suspended solids brought in by the flow and kept in suspension, but that part of them were brought up from the underlying sludge. As a detailed discussion of the movement of solids in the tanks was given in our third annual report (16), it will suffice to state that the opinion was expressed that the solid particles in the liquid are in constant motion or in a state of dynamic equilibrium. The action of the microscopic organisms on these particles caused them to disintegrate, liquefy or mineralize, and after partly settling out, to

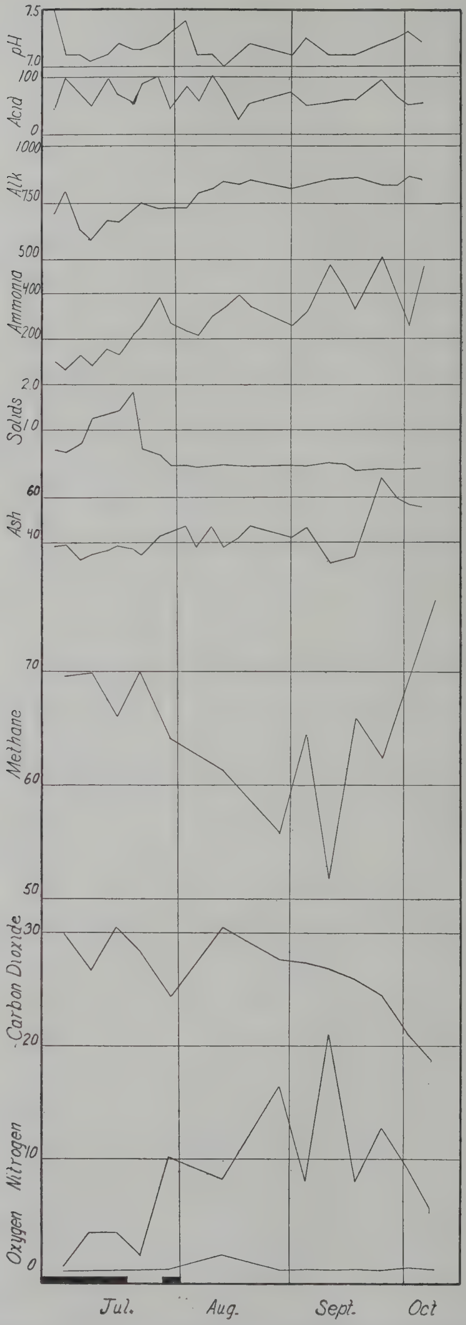


Fig. 13. Chemical Analyses of Tank 3 (Shaded Portions Indicate Tank in Operation)

be more and more mineralized. The result was that near the end of the experiment the total solids decreased and the ash content of the material in suspension increased by nearly 20 per cent.

Gas production, measured by suspending in the digestion compartment a large cone of known dimensions attached to a gas meter, was greatest during the periods of operation, except toward the end of the experiment when gas production increased again considerably. The composition of the gases remained fairly constant during the first periods of operating and resting of the tank, but changed materially during the second part of the long resting period. The carbon dioxide content of the gas dropped continuously from about 27.5 per cent. to less than 16 per cent. while the tank was resting. During the first periods of the experiment the methane fluctuated between 65 and 70 per cent., dropped to 56 per cent. during the first part of the long resting period, but rose with fluctuations to 76.5 per cent. toward the end. After reaching this high point, methane production suddenly decreased in spite of the fact that the CO_2 content decreased. At that time the nitrogen content rose suddenly from 4.9 to 28.8 per cent. No oxygen was present. The curves for gas production and gas composition obtained in our fresh solids digestion experiments (16, 17) are very similar to those presented for this tank. It has been found from a number of laboratory experiments that CO_2 production is high at the beginning and decreases gradually toward the end of the experiment. On the other hand, methane production is always low at the beginning and high at the end. It was found also that the nitrogen gas content, obtained by difference, in the laboratory experiments fluctuated considerably with the appearance of definite cycles. This is also true for the tank experiment. During the first stage of decomposition, CH_4 and CO_2 productions have a relation of about 70 to 30 respectively; during the second stage, a relation of about 60 to 25 with increasing amounts of nitrogen gas; and during the third stage, a relation of about 70 to 75 per cent. CH_4 and 15 to 20 per cent. CO_2. As proof for the assumption that there are different groups of organisms acting in succession, the nitrogen-volatile matter ratios were plotted in a former report (17, p. 59). It was shown that in the course of digestion the relative amounts of nitrogen in the volatile matter decreased and increased in cycles. From the nitrogen gas curves in figure 13 it will be seen that the nitrogen content of the gases produced fluctuated in a similar fashion.

Bacteriological

The method of study was the same as described in previous reports (15, 16, 17). The samples were brought into the laboratory, different dilutions made, and 1-cc. portions of these dilutions transferred into various media. The cultures were all incubated at 20 to 23° C., the plates and lactose tubes for a week and the other media for 4 weeks.

The results for tank 3 are shown graphically in figure 14. The total numbers of bacteria fell from 110 millions per cubic centimeter at the beginning of the study to 30 millions within 2 days, followed by

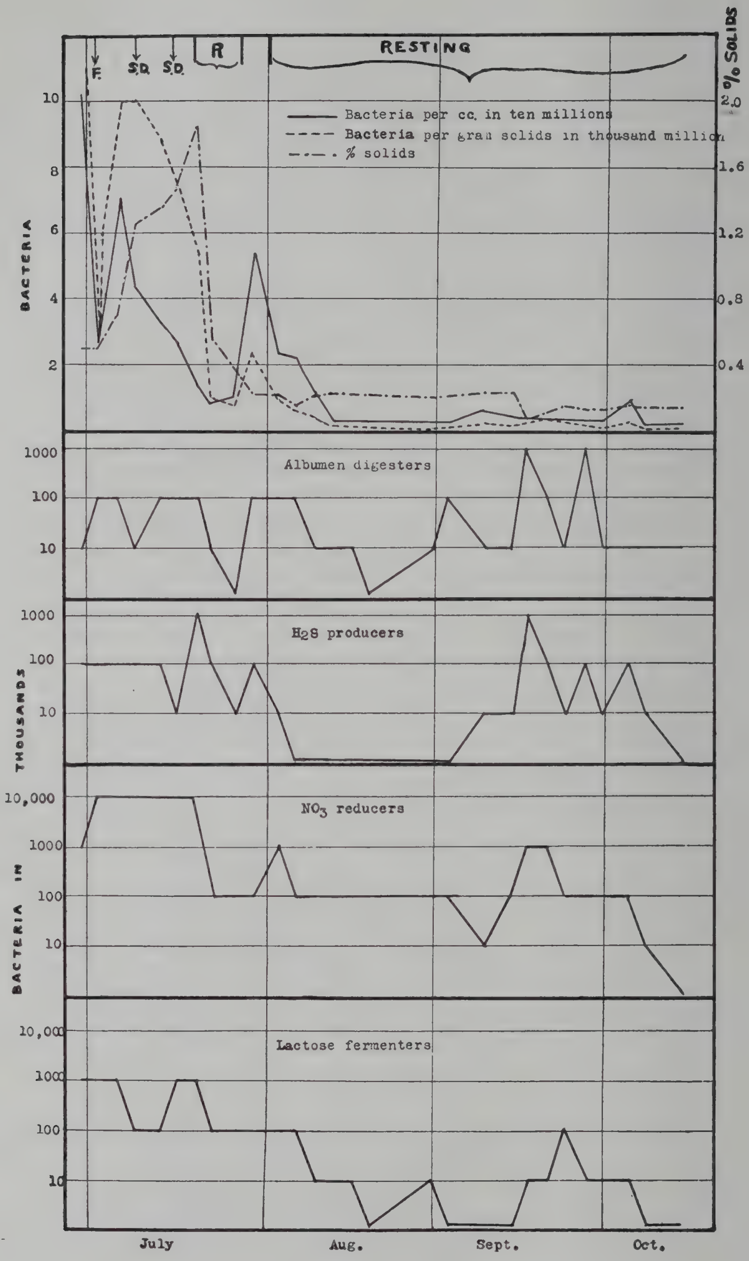


Fig. 14. Plate Counts and Groups of Organisms in Tank 3

an increase to the original high level, until July 20, when the numbers were back once more at a low level. That these high numbers of bacteria were due to the operation of the tank is evident, because as soon as the tank was put out of operation the numbers fell and remained at a low level and rose only temporarily when the tank was put into operation for a short while at the end of July. Sludge drawn twice during this first period of operation has also its effect in reducing the numbers of organisms, as has been observed before. However, the large numbers of bacteria during the operation of the tank are not due to foaming, for if such were the case increase in the per cent. solids should slightly precede or coincide with the increase in the numbers of bacteria. As can be seen from the curves, the per cent. solids reached a peak only after the numbers of bacteria showed a decline. That the large numbers of bacteria are not due to foaming is further borne out by the fact that there is a similar increase in the numbers of bacteria as pointed out above on the basis of per gram solids. Thus operation of a tank increases not only the actual numbers of bacteria proportional to the increase in solids in suspension in the liquid, but increases them in excess of this relationship. As a matter of fact the numbers of bacteria per gram of solids show a decrease while the per cent. solids are increasing. This demonstrates clearly that foaming is the result of bacterial action and not of the distribution of solids. Then what causes this increased bacterial activity during operation? It naturally must be due to increased food supply. If this food supply is in excess (beyond a definite ratio of ripe sludge and fresh solids) the activities are stimulated to such an extent that foaming takes place with consequent increase in the percentage (distribution) of solids in the liquid above the sludge.

In spite of the fact that there are considerable fluctuations in the numbers of the different groups of organisms, some general relationship can be noted. The numbers of albumen digesters, H_2S producers, NO_3 reducers, and lactose fermenters were as a rule high when the tank was in operation, with a tendency to decrease when the tank was out of operation. However, there was a decided increase in albumen digesters after the middle of August, and in H_2S producers after the end of August, in spite of the fact that the tank was still resting during this period. It is interesting to note that the rise in albumen digesting organisms preceded that of H_2S producers. This is natural, since the first group comprises organisms capable of attacking more complex proteins than the second group. The increase in these two groups during the last two months of study while the tank was resting, is indicative of normal digestion as is borne out by the curves for ammonia and methane. Coincident with the increase in these two groups, ammonia and methane begin to show decided increases. This indicates that after a tank is put to rest the different groups of organisms are undergoing some kind of a readjustment and regrouping among themselves and there is a period of time before the normal grouping is established and functioning properly. It further seems possible that the organisms giving positive tests in the different media are not the same in the last period as they are in the first. This is easy to see in view of the fact that many organisms of widely different groups are capable of growing and of bringing about these changes in the above media. Hence it can be assumed that in an operating tank where the relation of the incoming solids to ripe sludge is correct there will be a definite relationship between the flora responsible for digestion and the incoming flora which, although giving high counts as indicated by the above media, is ineffective if not inimical to normal digestion.

Zoological

The census of the protozoan fauna showed a decrease of more than 50 per cent. of the numbers after the sewage was diverted through tank 1 for preliminary sedimentation. When the total incoming solids decrease, the numbers of protozoa decrease also.

The tank was operating during July, and resting during August, September, and October. While the tank was operating the protozoa were five to ten times more abundant than during the period of resting in August and September (fig. 15). A high peak in flagellate numbers occurred during the middle of July when the tank was foaming. The zoological data obtained confirm previous observations made by Lackey (10, 17) that if the resting period of a tank is prolonged, the protozoa fall to a low level and remain there until the tank is again placed in operation.

During the resting of tank 3 the ciliates fell away and disappeared almost entirely. The ciliates which were present before the tank was allowed to rest were *Colpoda, Prorodon, Holophrya, Trimyema, Metopus,* and *Cyclidium.* Their total numbers never exceeded 4000 per cubic centimeter. A few amoebae, mostly *Hartmanella hyalina,* never rose above 400 per cubic centimeter in the counts. The flagellates were predominantly *Bodo, Tetramitus, Hexamitus, Cercobodo, Monas* and *Trepomonas. Oicomonas, Cercomonas, Euglena,* and *Notosolenus* were present in fewer numbers.

When the tank was not operating the active genera present became select. *Euglena* and *Chlamydomonas* seemed to thrive best in the resting tank. The chlorophyll bearing Euglena and the colorless type were present. The chlorophyll bearing organisms were abundant only near the surface.

TANK 5

Chemical

Tank 5 as described in a previous report had been emptied, altered and put into operation anew (with a certain amount of ripe sludge for seeding purposes) in April, 1924. As the tank was unable to take care of the incoming fresh solids during the first 5 months of operation, almost continuous foaming resulted. During practically the entire following winter this tank foamed continuously and was watched with a good deal of interest during the summer of 1925. Although fresh solids were added at a lower rate, because of the operation of tank 1 as a preliminary settling tank from which the fresh solids were pumped to a separate sludge digestion tank, this tank was foaming so badly during June that the flow chamber was covered with a thick foam and the tank had to be put out of operation. It was clear that our conclusion drawn last year regarding the incorrect relations of fresh solids and ripe sludge (17) was correct, and the tank was unable to cope with the fresh material in spite of the alteration. The supposition that possibly the effect of the alteration would be felt after more than one year's service could not find support. An attempt made to put the tank in operation again after

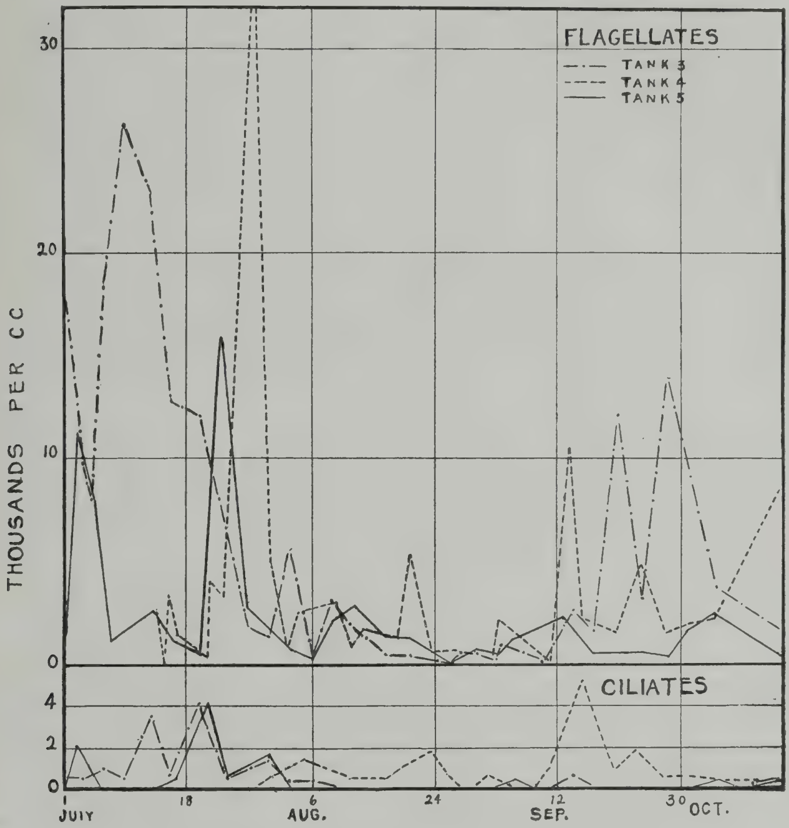


Fig. 15. Comparison of Protozoa in Tanks 3, 4, and 5

3 weeks' resting resulted in heavy foaming inside of one week and the tank was rested until the end of October.

The pH values obtained during the period of the experiment show that conditions in the tank were unbalanced. The fact that after 6 weeks' resting the contents of the tank were changing from 7.3 to the neutral point indicated that it was still on or near the "danger line." The total alkalinity as shown in figure 16, although comparatively low, dropped suddenly from about 1000 p.p.m to 375 p.p.m when the tank was put in operation. After some time of resting the total alkalinity increased, but remained at a low level for the whole period.

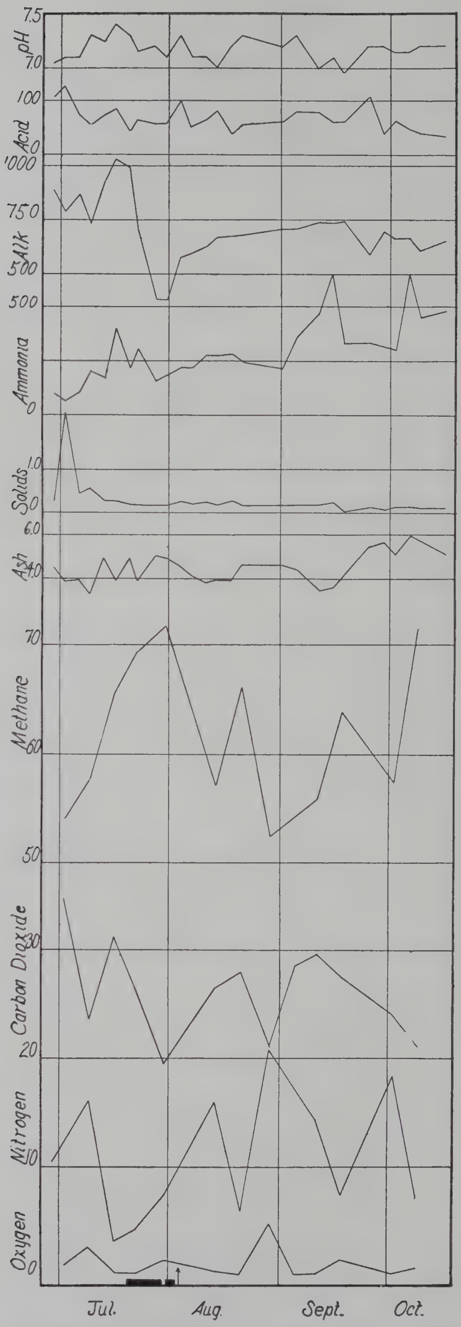


Fig. 16. Chemical Analyses of Tank 5 (Shaded Portions Indicate Tank in Operation)

Ammonia-nitrogen increased from about 100 p.p.m to about 400 p.p.m during the first resting period and decreased to about 280 p.p.m. during operation. During the second resting period the ammonia production increased considerably, which is correlated with the changes in the bacteriological flora. This percentage of solids and ash in the liquid was, after the tank was allowed to rest, substantially the same as for tank 3.

Methane and CO_2 production, as shown in figure 16, fluctuated considerably. In general methane production again followed the same course as mentioned in the discussion under tank 3. The percentage of methane was never higher than 72, and this occurred during the first few days of operation after a prolonged resting period. The same happened again at the end of the experiment after a long period of rest. It has been pointed out before that this comparatively large methane production coincides with the decomposition of more or less resistant carbohydrates. If a tank has been resting for some time these carbohydrates are attacked, giving rise to methane and if then after resting the tank is put into operation so that methane production is enhanced from the soluble sugars and starches, the total production and percentage in the gas of methane appear to increase considerably over ordinary production from continuous running tanks. If tanks are operated on a basis of sufficient ripe sludge to incoming fresh solids the percentage of methane should remain fairly uniform at a comparatively high level. In previous reports it has been shown that a high percentage CO_2 production—with often subsequent low methane production—is usually associated with troubles. The reasons indicated in earlier reports are considered more fully in the general discussion.

Bacteriological

Tank 5 is similar to tank 3 in broad outline (fig. 17). At the start the tank was put to rest on account of foaming, and the numbers of bacteria decreased, whereas the per cent. solids showed an inverse relationship, bearing out the conclusion reached in the discussion of tank 3. When the tank was put into operation again on July 20 the numbers of bacteria per cubic centimeter showed some increase, while the bacteria on the basis of dry material showed a very decided increase, followed by a drop. Another peak occurred when the tank had been resting for some time, followed by a decrease; and toward the end the numbers of bacteria per gram of dry material showed another increase. The tendency with the groups of organisms is the same as above. During the comparatively short periods of rest there was a decrease in the numbers of groups of organisms studied, followed by a sharp increase on resumption of operation. On prolonged resting, however, these groups decreased decidedly and after remaining for a period at this low level, the duration of the period being different with different groups, there was another increase. The phenomenon as well as the explanation of it is the same as the one offered in the discussion for tank 3. In

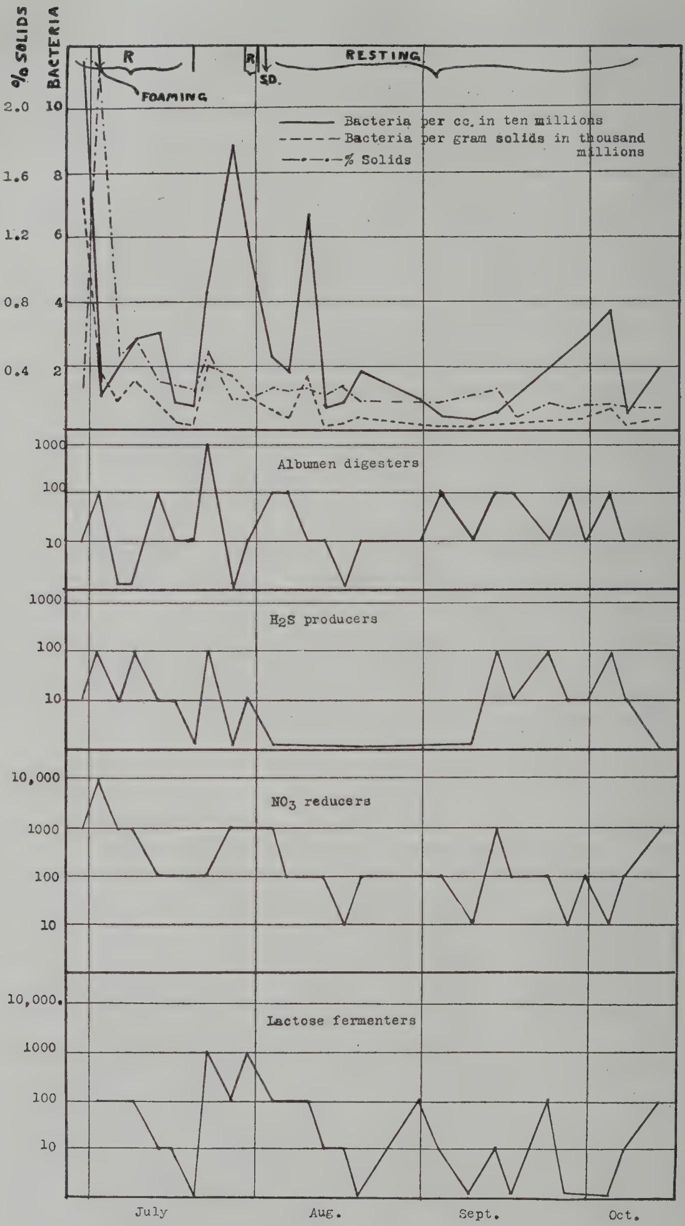


Fig. 17. Plate Counts and Groups of Organisms in Tank 5

comparing these two tanks one is struck with the similarity of curves in each case. In both cases while the tanks were resting the albumen digesters came to a low level, followed by a sudden rise, whereas the H_2S producers remained in the low level for over a month before the final rise. The lactose fermenters also came to a very low level two weeks after the tank was put to rest, and from there on indicated quite regular fluctuations. It is possible that the lactose fermenters during the periods of operation and rest are not the same, the high numbers of these organisms in the previous case being due to intestinal organisms which are reduced in number when the tank is resting and are followed at the end by a different type of lactose fermenters which are carrying on the digestion. As in tank 3, correlative with these changes in the flora from the operating to the resting tanks, there is the change in the composition of the gas. Methane increases at the beginning and drops after the tank is put out of operation to increase again toward the end in a similar way as do the groups of bacteria mentioned above. This is accompanied with increasing amounts of ammonia-nitrogen.

Zoological

A comparison of the fauna of tank 4 with that present during the time of the experiment in tank 3 shows (fig. 15) a striking similarity during resting and operation. When the solids in suspension decreased protozoa decreased also. However, after a prolonged period of resting, protozoa increased again somewhat in tank 3, but not so pronouncedly in tank 5. The rise in numbers was due to an organism which apparently under certain conditions multiplies rapidly and finds the tanks a convenient habitat. This organism, *Euglena,* thrives better in a resting than in an operating tank. During the operation period practically no *Euglena* occurred, but the longer the tank was resting the higher the numbers of this protozoan rose. In a former report (16) a curve was presented on the relation between pH values and "total" animals in seeded fresh solids. Shortly after incubation the protozoa decreased considerably, but rose very high around the neutral point, followed by a decrease and again followed by a marked increase in numbers toward the end of digestion. From studies on fresh solids digestion (17) it has been concluded by us that there are mainly three kinds of materials attacked in succession; namely, soluble carbohydrates, protein materials, and more resistant carbohydrates. In the second period comparatively large quantities of amino acids were found. This second period reaches its peak around the neutral point, when amines increase. It must be borne in mind that at this time the more resistant carbohydrates are being attacked as well, but possibly not intensively or on a large scale.

It is well known that the chlorophyll bearing protozoa, Euglena, can live more or less perfectly as a saprozoic organism, especially when the organism loses its color. The loss of color of the animals in Imhoff tanks and in fresh solids digestion has been demonstrated several times in our laboratory. Calkins (2) states that it was long ago suggested hypothetically, and later verified experimentally, that organic matters are taken into flagellates (Euglena) from the surrounding medium. Zumstein (21) endeavored to find out whether such organic matter consists of carbon compounds or of nitrogen and ammonia compounds, and found that in a bacteria-free medium, peptone with the addition of some carbohydrates gave the best results. Ternatz (20), confirming Zumstein's main results, found that the best sources of nitrogen were some amino acids, whereas ammonia compounds were generally detrimental. Calkins concludes that it appears probable that saprozoic forms of protozoa get their main nourishment from amino-acids derived from the disintegration of animal and plant matter (through the agency of bacteria) and from carbohydrates in solution. It will be noticed from our curves, both for tanks 3 and 5, that protozoa fluctuated considerably with the fluctuation of ammonia production. The number of protozoa, especially in tank 3, was high after the tank had been resting for about 6 weeks, at which time it might be expected that the protein materials were broken down and comparatively large quantities of amino-acids were present.

TANK 4

Chemical

The main object of the study on tank 4 was to determine the effect of lime in an operating tank on the digestion process, as a large scale check on our laboratory results. This tank had been foaming to such an extent that the scum was flowing over into the flowing-through channels. The reaction of the tank contents was pH 6.6 on July 13. The amount of lime necessary to change the hydrogen-ion concentration of the tank contents from 6.6 to 7.4 was calculated and added to the digestion chamber by pumping liquid from one digestion compartment to the other. The lime, added to the stream of liquid material with a dry feed constructed by the plant operator, insured good mixing in this simple manner. After the addition of the lime the tank was rested for a few days, put into operation for a few days, sludge drawn and kept thereafter in continuous operation.

The chemical results are graphically shown in figure 18. The pH value was maintained at 7.3 for a month and thereafter at 7.2. The total alkalinity dropped materially on account of sludge drawing, but rose again to a level of about 1350 p.p.m. As was stated above, all analyses were made on the liquid between scum and sludge in the digestion compartments. The samples were taken from the level of about 7 feet in the middle compartment. After the addition of the lime, ammonia production decreased from 350 to 150 p.p.m., but rose rapidly again to 400 p.p.m. During the first 6 weeks of the long operation period, the ammonia-nitrogen fluctuated between 350 and 450 p.p.m. and rose very sharply to 650 p.p.m., followed again by a slower decrease back to about 400 p.p.m. The solids in the liquid remained fairly constant, usually less than 0.5 per cent., indicating that sludge movement, as it occurred in the operating periods in tanks

3 and 5, was not taking place. From the beginning of the experiment the tank was watched for scum formation. As pointed out above, the tank was foaming and a scum layer of several feet was present at the time lime was added. Two hours after the addition of the lime, 2 inches of scum was measured, two days later ½ inch, and 3 days later ¼ inch was still present. After this date no scum was found in the tank until the end of the experiment. Nothing was done to this tank until the spring of 1926, when the tank had accumulated 1½ feet of scum and the pH was 7.0. Shortly after this the scum began to rise and foaming resulted.

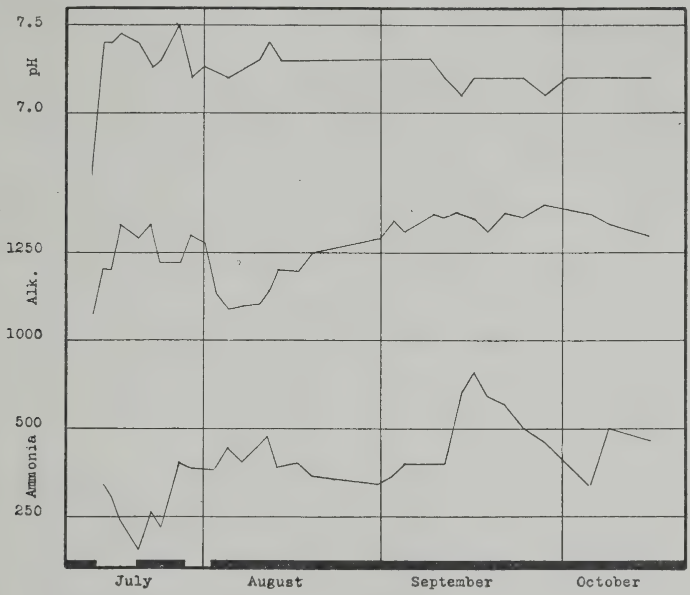


Fig. 18. Chemical Analyses of Tank 4 (Shaded Portions Indicate Operation of Tank)

Bacteriological

After the tank contents were adjusted to 7.4 and a short period of rest the tank was put into operation with subsequent increase in the numbers of bacteria both on the wet and dry solids basis (fig. 19.) The numbers of bacteria decreased when the tank was put to rest again for a short while. After August 4 the tank was operated continuously in contrast with tanks 3 and 5, which were resting. In spite of the continuous operation, the numbers of bacteria were not excessively high, as ordinarily would be the case in an operating tank. They maintained a fairly high and uniform average, which would tend to show a balanced condition in spite of the constant operation. The different groups also soon recovered and maintained a high level after the initial decline due to resting had passed. This is especially

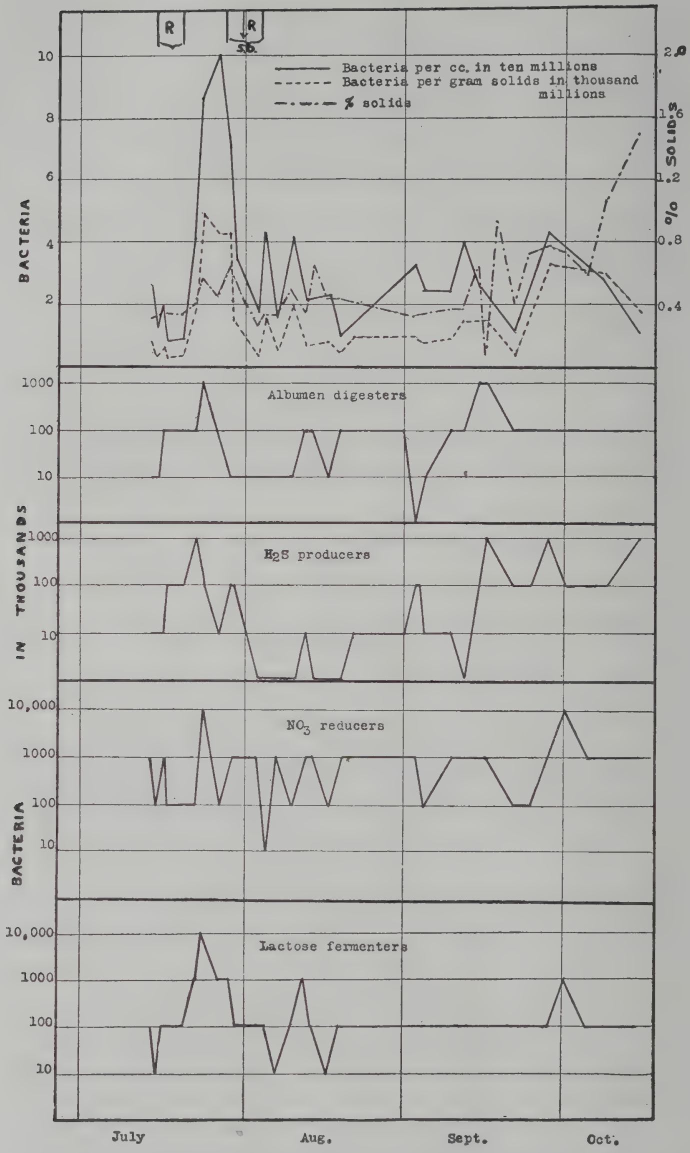


Fig. 19. Plate Counts and Groups of Organisms in Tank 4

true of the albumen digesters and the H_2S producers. The period of rest was short and soon after the tank was operating they showed an increase, followed by a sharp fall, first in the albumen digesters and later in the H_2S producers. The increase after this drop was immediate in both cases, H_2S producers following the albumen digesters closely. Similarly the lactose fermenters (in spite of the constant operation) maintained a remarkably uniform and fairly low level, indicating that digestion was proceeding normally.

All the data seem to indicate that in spite of 2½ months' constant operation this limed tank was at least as good bacteriologically as the other tanks that were resting. This is indicated by the fact that the total numbers did not show any excessive figures or rapid fluctuations. Moreover, the different groups became established at least as quickly and maintained as high and uniform a level as the resting tanks.

Zoological

Routine enumeration of the animal population was begun July 13, and as figure 15 indicates, there was a sudden rise in the number of flagellates immediately after operation began. After August 1, the protozoa in tank 4 remained less than 15,000 per cubic centimeter, although it was operating continually. In contrast, the numbers were materially higher in tanks 3 and 5 when they were operating. The effect of lime and reaction on the protozoa is discussed more in detail in another part of this report. The genera of flagellates present were *Bodo, Thepomonas, Tetramitus, Euglena, Hexamitus, Cercobodo, Monas,* and other flagellates. The ciliates found were *Colpoda, Holophrya, Cyclidium, Colpidium, Metopus,* and *Hexotricha. Saprodinium* was absent during the summer, but appeared in October.

Discussion

A comparison of the results obtained on these three tanks brings out one point very definitely; namely, the effect of the reaction of the medium on the behavior of the tanks. The untreated tanks, regardless of the fact that one was rebuilt for overcoming difficulties, had to be shut down after a short period of operation on account of foaming, whereas the treated tank, which had been foaming previous to liming, was able to run for several months without showing this particular difficulty.

The additions of lime to a foaming tank resulted in its correction for several months. Corrections made occasionally are important, but it is far better to have a plant under constant (scientific) control. The production of acids and acid materials in the course of digestion increases with time, and results in retardation of activities of groups of organisms responsible for more complete decomposition. The object of control of a plant is not so much to correct difficulties as to forestall these difficulties. Prevention of difficulties will prove to be simpler and less costly, as pointed out elsewhere in this report.

A daily comparison of the percentage of solids and of the protozoan numbers from tanks 3, 4, and 5 appears to reveal a direct relationship between the amounts of solids present in the liquid and the numbers of protozoa. Tabulation of data indicates the rise in numbers of protozoa per cubic centimeter when the per cent. of solids is greatest.

On the other hand, although the numbers of bacteria in general was increased with the increase in per cent. solids and decreased with a decrease in solids, the peak of bacterial numbers was reached several days before the solids reached their maximum distribution. A few results, plotted in figure 20, bring this out more clearly. Calculating the numbers of protozoa per gram of dry material, shows that with the increase of solids protozoa increased in direct proportion, but decreased more rapidly with a decrease in solids. Since the bacteria reached a peak before the peak of solids, it is clear that the protozoa were not directly related to the bacteria. Moreover, these protozoa were all sapropelic small flagellates and not bacterial feeders. From July 2 to July 6 the solid concentration increased in the liquid, on July 9 partly decomposed material (mostly scum) was pumped out of the tank, causing an additional increase in the percentage of solids in the liquid. It has been demonstrated by Lackey (10) with a number of experiments that flagellates are never as abundant in the scum or sludge as in the liquid. The distribution of solids as such, therefore, could not cause the rapid increase of the protozoa. It seems then that the materials on which these animals were living were soluble intermediate decomposition products from bacterial action in scum or sludge which were distributed with the solids. The fact that the protozoa died off more rapidly than the solids settled out is additional evidence. It has been pointed out before that numbers of protozoa are a good index of disturbance in a tank. Assuming that these flagellates live on certain intermediate decomposition products and a distribution of these products causes a proportional increase in animals, the question is: What are these products? Examination of the chemical data shows that during the period under discussion ammonia-nitrogen was low and practically constant with a rise of solids,

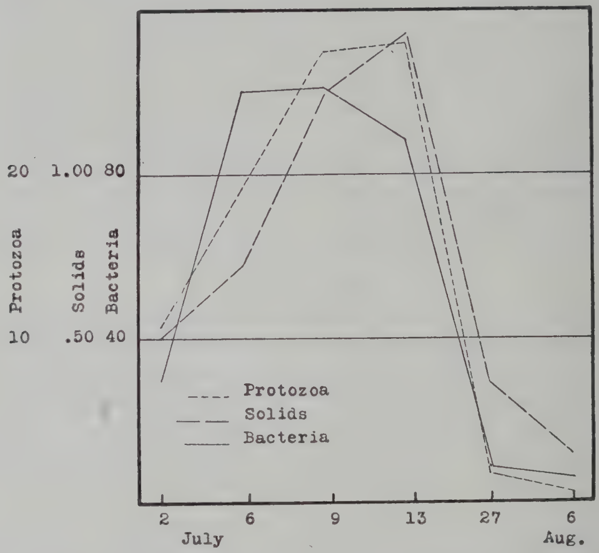


Fig. 20. Comparison of Bacteria and Protozoa on Basis of Dry Solids

but increased rapidly with the drop in solids. This corresponds to the rise and fall in the numbers of protozoa. On the other hand, CO_2 and CH_4 production was high with the increase in solids and lower with the decrease. The measurement of the end products is not a direct evidence of the materials available for these organisms, but indirectly it would seem that intermediate carbohydrate decomposition products were especially responsible for the increase in protozoa. These products are of course produced by bacterial action, and the fact that protozoa as a rule follow the bacteria (15, 16, 17) would seem to make them dependent not only on the numbers, but also on the kind of bacteria present. Disturbances, like foaming in the tanks, are ordinarily indicated by acidity of the liquid and by high numbers of protozoa. The acidity is caused mainly by carbohydrates decomposition. If a tank is not digesting well, or in other words, if these carbohydrate decomposition products are accumulating, acidity increases, and subsequently the numbers of protozoa living on these accumulated product increases, provided the accumulation is not too great.

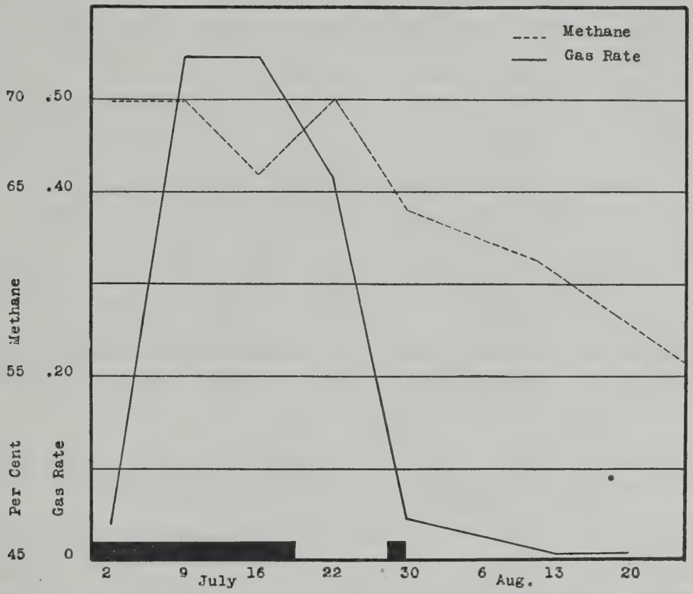


Fig. 21. Rate of Gas Production and Methane Content in Tank 3 (Shaded Portion Indicates Operation of Tank)

Gas production changed considerably during the operating and resting periods. Figure 21 shows the rate of gas production from tank 3. The gas was measured with an ordinary meter attached to an iron funnel with its wide opening submerged in the digestion compartment. The flow is given, for comparative purposes, in cubic feet of gas per square foot of tank area in 2 hours. About two weeks before the tank had to be rested on account of foaming, the rate of gas production was greatest. The methane content was about 70 per cent. and although gas production remained at a high level when foaming was in progress, the percentage of methane dropped. As soon as the tank started to rest, gas production increased with an increase in methane content, but the latter decreased gradually with the time of resting to about 56 per cent., while gas production became very low. A discussion about gas production in the course of digestion will be found elsewhere in this report (see p. 463). Compare also the laboratory findings already published (15, 16, 17).

Summary

The solids retained in the tanks increased greatly, because of an effort of the operator to improve the character of the effluent. As a consequence, a larger quantity of sludge had to be handled and conditions were opportune for study.

A comparison of two Imhoff tanks, one treated with lime to adjust the reaction of its contents, and the other untreated, showed that the treated tank gave no sign of foaming and was free from scum for several months in spite of the fact that it was continuously operating, whereas the untreated tank had to rest and could not be put into operation for a long time on account of heavy foaming.

Gas production and composition change with the operation or resting of a tank. During the first few days of operation after a prolonged resting period, methane production is highest.

Protozoa increased in direct proportion to the percentage solids increase, but bacterial numbers reached its peak before the percentage solids was highest.

TABLE 7

Statement of solids collected in Settling Compartment of tanks at Plainfield Joint Sewage Works

Month	Flow	Solids		Solids Retained	Solids Retained	Volume (5% Solids)
		Influent	Effluent			
	M.G.D.†	*p. p. m.*	*p. p. m.*	*p. p. m.*	*pounds*	*cubic feet*
Dec., 1924	3.1	225	137	88	2177	698
Jan., 1925	No analysis					
Feb., 1925	3.7	174	114	60	1851	592
Mar., 1925	3.5	207	119	88	2568	822
Apr., 1925	3.1	214	143	71	1834	508
May, 1925	3.0	254	106	148	3702	1184
June, 1925	3.2	232	63	169	4503	1440
July, 1925	3.1	227	82	145	3745	1198
Aug., 1925	3.1	251	62	189*	4887	1564
Sept., 1925	2.9	189	59	130*	3144	1006
Oct., 1925	3.1	231	45	166*	4808	1537
Nov., 1925	3.2	186	63	123*	3202	1024
Dec., 1925	3.2	189	64	125*	3253	1047
Average	3.2	216	88	125	3223	1052
Average after May 1	3.1	220	68	152	3877	1241

* Double settling total 57 minutes August to December inclusive (by tests).

† Million gallons daily.

Separate Sludge Digestion Tank Experiments

Introduction

After considerable experimentation in the laboratory and in the field, the superintendent of the Plainfield plant built a square earthen separate sludge digestion tank with a capacity of about 25,000 cubic feet and with a floating wooden cover. The cover was placed in such a way that it fitted rather closely to the walls, the object being to keep the scum formed submerged, to insure better anaerobic digestion and to prevent gases and odors from escaping. This tank was preliminary in character and after considerable data on the digestion of the sludge were obtained, he made plans for two additional, 16-sided concrete tanks, which are under construction at this writing.

Previous to August 20, 1925, an amount of 5,500 cubic feet ripe sludge was pumped into the tank and with an addition of 3,200 cubic feet fresh solids on August 22, the tank was started. Fresh solids were added every 2 or 3 days up to October 16 and our experiments were begun at the latter date. The fresh solids were pumped from an Imhoff tank used as a preliminary settling tank. Up to October 16 the total amount of fresh solids added was 63,900 cubic feet, making a total of 69,400 cubic feet. During this time of operation (2 months) 29,600 cubic feet was taken out. At the beginning of our experiment the tank contained 15,000 cubic feet of material. The fresh solids pumped in were adjusted with hydrated lime to a pH value of 7.3. During the period of the experiment (6 months) the following chemical analyses and determinations were made: Amount of gas produced, composition of gas (CO_2, O_2, CH_4, H_2, N_2), pH values, total acidity, total alkalinity, ammonia-nitrogen, solids and ash. Bacteriological determinations included total numbers and different groups. Zoological determinations were made on numbers and kinds. An automatic record was made of the temperature in the tank about 6 feet from the top.

Analyses made on the first day of the experiment gave the following results:

	Liquid	Sludge	Gas
pH	7.2	7.15	CO_2 33.2%
Acidity	68 p.p.m.	80 p.p.m.	O_2 0.1%
Alkalinity	1370 p.p.m.	1380 p.p.m.	H_2 0.0%
Ammonia	500 p.p.m.	300 p.p.m.	CH_4 49.0%
Solids	7.7%	7.7%	N_2 17.7%
Ash	36.6%	37.7%	Total 2200 cu. ft.
Bacteria	56 millions*	46 millions*	per day
Protozoa	152,000*	8,700*	
Temperature	68° F.	68° F.	

* Per cubic centimeter.

Results

Chemical

As has been mentioned above, the laboratory determinations were started after the tank had been in operation for 60 days. During two months the tank had a chance to come to a certain equilibrium, and the experiments were therefore started at a time when possible initial difficulties in operation were adjusted and corrected, although the time of the year was least fitted for maximum results. The chemical data obtained both for liquid and sludge are graphically presented in figures 22 and 23. A comparison of these two figures shows that the general fluctuations are practically identical. The reason why these duplicate determinations were made and here presented was to check up results obtained in the laboratory and on Imhoff tanks where the liquid gave a true indication of the activities in the bottles and tanks. As could be expected, the same held true for the separate sludge digestion tank. For future studies it will therefore be immaterial which phase of the tank contents—liquid or sludge—is studied; as long as the determinations are made on the same layer throughout,

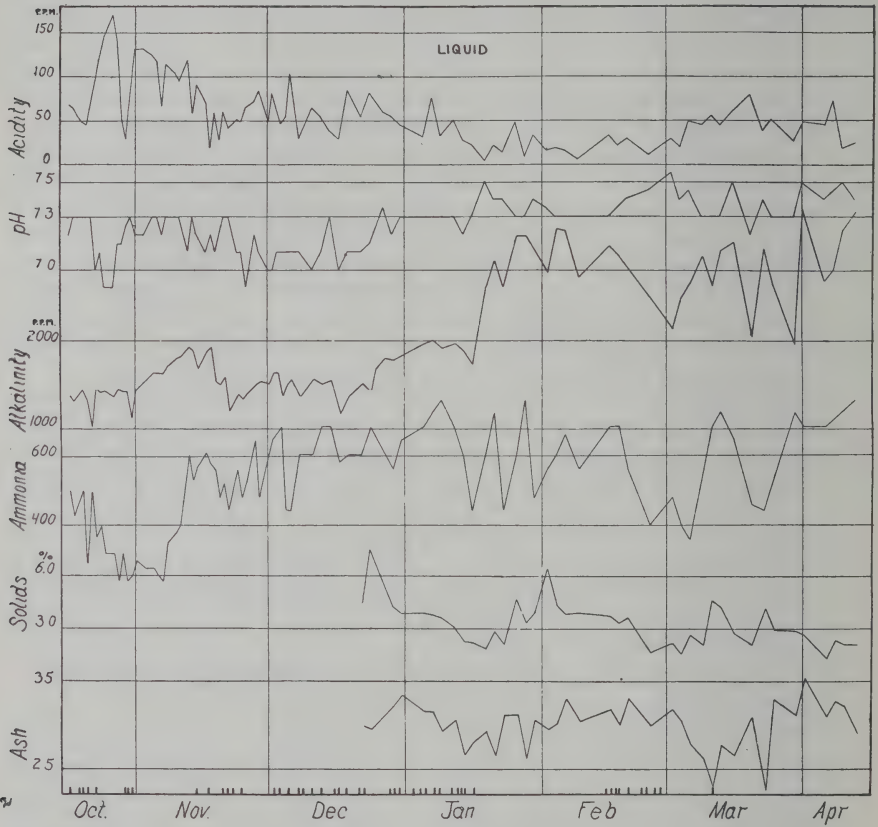


Fig. 22. Acidity, pH, Alkalinity, Ammonia, Solids, and Ash in the Liquid of the Separate Sludge Digestion Tank (Short Lines at Bottom Indicate When Solids Were Added)

the experiment will be comparable. In one case it may be easier and simpler to take samples from the liquid layer and in another to draw some sludge. If in the construction of a separate sludge digestion tank provisions are made to draw small quantities of sludge sufficiently near to the bottom to give a comparatively good sample, determinations on the sludge should be favored, but in case the sludge pipe reaches only partly down into the tank, sampling from the liquid layer would give a better index of activities.

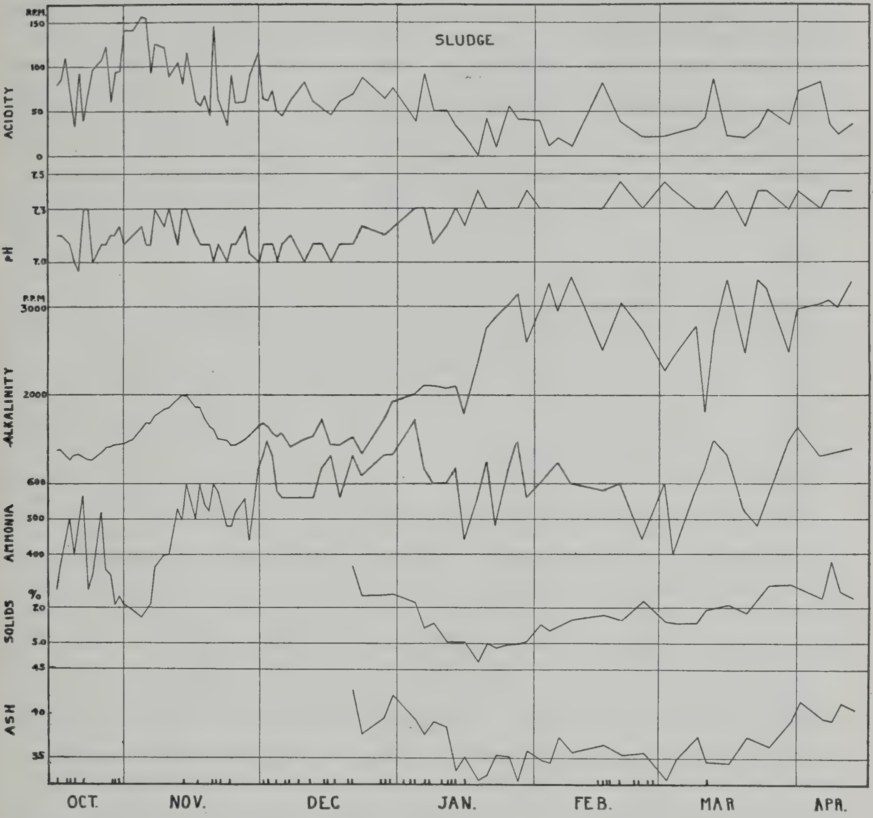


Fig. 23. Acidity, pH, Alkalinity, Ammonia, Solids, and Ash in the Sludge of the Separate Sludge Digestion Tank (Short Lines at Bottom Indicate When Solids Were Added)

Since the tank could handle only a part of the total solids, it was practically impossible during the time of the experiment to add daily the required amounts of fresh solids. One of the Imhoff tanks which was converted into a preliminary settling tank collected far more solids than could be daily disposed of into the tank, and consequently when the separate sludge digestion tank was full it had to be allowed to rest for shorter or longer periods. The total addition of fresh solids was 963,000 cubic feet (95 per cent. moisture) during a period of about 180 days. The amount of material present when the experiment was started was about 15,000 cubic feet (92.3 per cent. moisture) comparable to about 23,000 cubic feet of 5 per cent. solids. A calculation of the rate of addition of fresh solids on a daily basis shows an addition of 2.3 per cent. (dry solids).

During the first month of the experiment, 17,400 cubic feet fresh solids were added. This amount was increased considerably during the next two months, followed by one month's rest, followed again by a brief period of addition; and finally the tank was allowed to rest for 6 weeks, after which the experiment was terminated. The short lines at the bottom of figures 26, 27, 28 indicate the dates when fresh solids were added, whereas figure 24 shows the actual amounts in cubic feet.

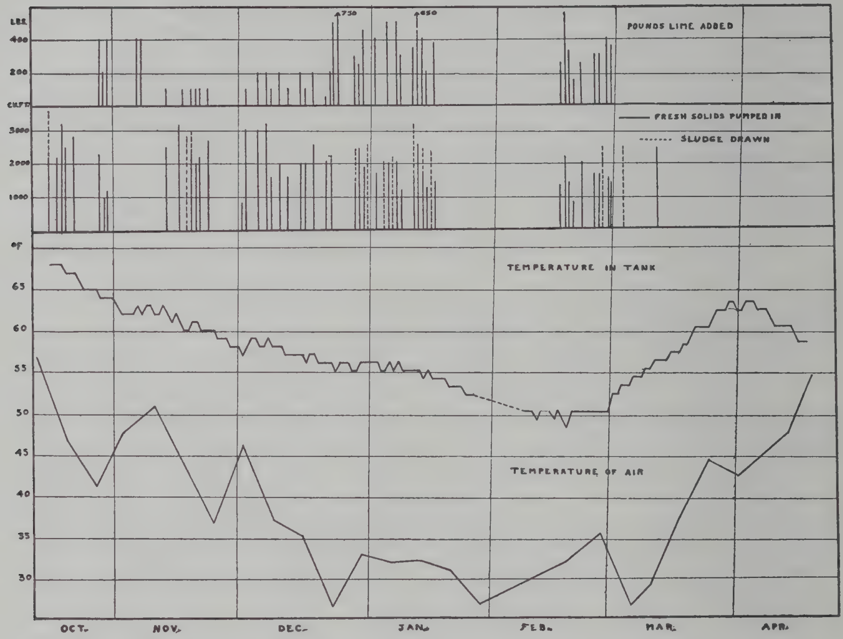


Fig. 24. Lime Added, Fresh Solid Pumped in, Sludge Drawn, Temperature of Air and of the Contents of the Separate Sludge Digestion Tank

The period of experimentation can be divided conveniently into an operating and a resting period, and this division will be followed in the discussion for no other purpose than bringing out reasons for fluctuations in the curves. Since the general tendency of the curves obtained for sludge are the same as for liquid only, those for the former will be used for detailed discussion (fig. 22 and 23).

At the beginning of the experiment total acidity was generally higher than during the later stages. The rises in acidity do not follow the additions of fresh solids, nor the resting periods. The general trend of the curves is the inverse of the total alkalinity curve, and the relation to the ammonia curve is only very general. During the first 6 weeks of the experiment it was noted that the curve for methane was very similar to the total acidity curve, but with the advance of time this similarity was lost.

During the first half of the experiment the pH values recorded reached 7.3 only a few times, whereas during the second half the pH values were practically always 7.3 or above. The trend of this curve naturally can be directly correlated with the total alkalinity curve, but it is worthy of note that the curve for the CO_2 content of the gas is in general inverse to the pH curves. In a forthcoming publication, on the effect of temperature in combination with reaction upon sludge digestion, the reasons for this phenomenon will be discussed at length; suffice it to say here that the type of digestion is influenced by the reaction of the medium and also by the composition of the gas produced.

The behavior of the tank is indicated in a general way by the curve for total alkalinity. Starting with 1370 p.p.m., it rose gradually during the first 3 months to 2000 p.p.m., dropped back to slightly above the original level, but rose rapidly to about 3000 p.p.m. in the fourth month, reduced somewhat in the fifth, and rose again to the high point during the last month of the experiment. It will be noticed that the rapid rise occurred during the comparatively long period of rest. The sudden drops in alkalinity are directly related to sludge drawing.

In general the curve for ammonia-nitrogen is directly related to the additions of fresh solids. It will be noticed from the curves that the ammonia content was highest when fresh solids were added and comparatively lowest when the tank was resting. Examination of the data obtained reveals the fact that the rise of ammonia is usually slightly behind the additions and that with the accumulation of the solids, ammonia increased. This is to be expected since decomposition of nitrogenous material follows the breaking down of the soluble carbohydrate materials.

The average solids content of the sludge during the second half of the experiment was 6.5 per cent., whereas the average solids content of the liquid was 3.3 per cent. During the addition of fresh solids (5 per cent.) the solids in the sludge dropped gradually from 7.7 per cent. to as low as 4.7, but after the tank was allowed to rest solids in the sludge increased until at the end the percentage of solids was 7.6.

The ash content of the sludge dropped from about 39.6 to 35 per cent. (in a few instances even below), but the percentage gradually came back to the original when the tank was resting, and at the end, when the tank was resting, the percentage was 40.6. The average ash content of the sludge was 37.4 per cent. The ash content of the fresh solids varied between 22 and 24 per cent. There was an average percentage increase in ash of about 50 per cent. over the original fresh solids.

The gas production from the tank during the first six weeks of the experiment is shown in figure 25, together with the sludge present in the tank and the additions of fresh solids. During this period 40,000 cubic feet fresh solids were added and the total gas production was 82,400 cubic feet. At the beginning of the experiment 23,000 cubic feet fresh solids (on a basis of 5 per cent. solids) was present in the tank. The total amount of sludge was 62,100 cubic feet. On this basis gas production was 1.32 cubic feet per cubic foot of sludge. Twice during this period the meter froze and no accurate record could be obtained. From figure 25 it can be seen that after November 8 the gas production was decidedly lower (except one day, November 16) than before that date. This occurred after the tank had been resting some time and the temperature had gradually dropped from 68° to 62° F. After the temperature dropped below 60° F. gas production practically stopped and measurements were discontinued. When the gas production is taken during the first 24 days and compared with the amount of sludge in the tank and fresh solids are added it is found that the total gas production was 65,500 cubic feet, the amount of fresh solids added 17,400 cubic feet, or a total of 40,400 cubic feet of material in the tank. The amount of gas per cubic foot of material in the tank for this period was 1.62 cubic feet. Assuming that the sludge in the tank at the end was in the same stage of decomposition as at the beginning and taking the fresh solids added as a basis for comparison, we find 3.74 cubic feet of gas produced per cubic foot of fresh solids. Calculating the gas production on the basis of dry solids, we find for the whole period

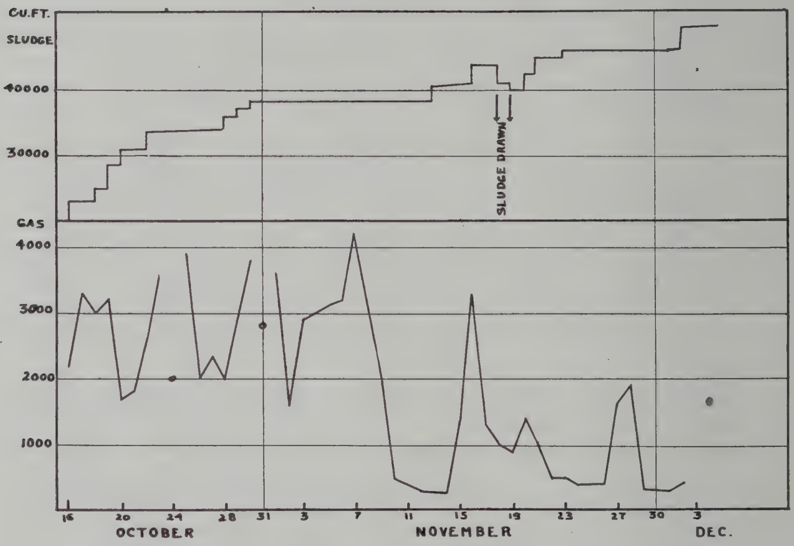


Fig. 25. The Rate of Gas Production and Amounts of Sludge Present in the Separate Sludge Digestion Tank

24.3 cubic feet of gas per cubic foot of solids, and for the first 24 days 30.0 cubic feet of gas per cubic foot of dry solids, or on the basis of fresh solids added, a total of 72.5 cubic feet of gas per cubic foot of dry solids. It should be borne in mind that the tank was by no means air-tight and gas was escaping continuously through small cracks and along the edges.

The quantity of gas produced—leaving aside loss—from material in the tank was below the quantities obtained in carefully controlled laboratory experiments. It has been found by Bach and Sierp (1) and also by us that the possible amount of gas produced from material carried to complete digestion is at least 250 cubic feet per cubic foot dry organic material. This quantity can be increased by a change of reaction. In this experiment the amount of gas per cubic foot of organic matter was approximately 100 cubic feet. Since the possible gas production from material brought to complete digestion is from 250 to 350 cubic feet per cubic foot of organic matter, it would seem that in the first 24 days of the experiment an equivalent of at least from 30 to 40 per cent. of the fresh solids added was digested. On this basis the tank would have taken care of considerably less fresh solids than it actually did. In a former publication (17) attention has been drawn to the fact that under certain conditions liquefaction can be induced. The laboratory experiments show that at a pH value of 7.3 liquefaction overbalances gasification. The tank contents were kept during the 24 days under consideration at an average pH value of slightly below 7.3 and the conclusion might be drawn that during this part of the experiment the digestion processes were mainly in the direction of liquefaction.

The composition of the gas during the entire period is shown graphically in figure 26. Occasionally analyses for hydrogen were made, but this gas was never found. During the first part of the experiment hydrogen sulfide was noticeable, but decreased later. At the beginning of the experiment methane production was low, but increased rapidly to an average of 72 per cent. After about one month the percentage of methane in the gas decreased to 58 per cent., and during the next month the average was about 66 per cent. In the second half of December the percentage of methane rose again and was almost persistently between 70 and 80 per cent. until the beginning of March, when it dropped again below 70 per cent. The fluctuations in CO_2 content curves were in general the inverse of those for the methane content. During the first part of the experiment the percentage of CO_2 fluctuated between 21 and 33 per cent., whereas during the second half the fluctuations were between 13 and 27 per cent. A comparison of the curves for pH values and alkalinity (fig. 23) with the curve for percentage of methane shows that there is in general a direct relation. With pH values below 7.3 the average methane content is about 68 per cent., whereas with pH values of 7.3 and above the average methane content is about 75 per cent. An exception might occur when the material has been digesting for some time (when no fresh solids are added). The relation between pH values and CO_2 content of the gas is also quite definite, but in the reverse order from the methane percentage. The same holds for the production of total alkalinity. The data and curves apparently do not show any relation between the ammonia-nitrogen production and the composition of the gas. A more detailed discussion on this phase of the problem, however, will be published later.

The daily temperatures of the tank, determined approximately half way between top and bottom by a self-recording thermometer, together with weekly averages of air temperatures (also determined by a self-recording thermometer) are plotted in figure 24. At the beginning of the experiment the temperature of the tank contents was 68° F., which in stages gradually dropped to as low as 48° F., on February 15. Barring this lowest temperature for one day, it is fair to say that the temperature dropped from 68° to about 50° F.

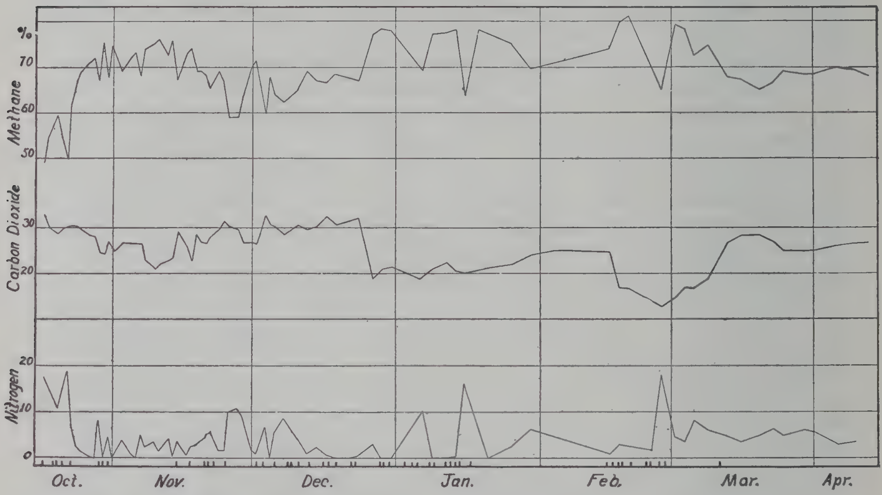


Fig. 26. Composition of the Gas from the Separate Sludge Digestion Tank

On February 26 the temperature in the tank started to rise gradually. This was because a ¾-inch iron pipe, through which hot water was flowing, had been placed in the tank. Heat was applied on February 22, and four days later the temperature began to rise. The curves show that the initial rise took place at the time when the air temperature was still dropping. Shortly after heating was discontinued the temperature in the tank dropped rapidly in spite of the rising air temperature. During this time no fresh solids were added; therefore, the rise and fall of the temperature in the tank were due exclusively to the heat applied. While the tank was heated the superintendent kept an accurate record of the amount of coal used. From his records he calculated that an average of 150 pounds of soft coal per day was needed to raise the temperature of the tank contents from 50° to 63° F. Since the average air temperature during the experiment was lower than the temperature of the tank contents, it is fair to assume that the effect of the air was not favorable for raising the temperature in the tank. It is clear that, since it took

1 pound of coal per day to heat 1000 pounds of material 13°, the amount of coal for maintaining the temperature at a certain degree in the fall and throughout the winter will be materially less than these figures. We believe that the practicability of maintaining a comparatively high temperature in a sludge digestion tank is demonstrated.

It is of interest to compare the trend of the temperature in the digestion chamber of an Imhoff tank with the temperature in the separate sludge digestion tank.

From records taken in former years it is known that the temperature of the settled sewage in the tank is practically the same as the incoming sewage. A few figures taken at random during the year (table 8) will suffice to illustrate this. Unfortunately our record for the temperature in the Imhoff tanks for the period of experimentation with the separate sludge digestion tank is incomplete. From the available data it appears that during December, January and February the temperatures in the Imhoff tanks and in the separate sludge digestion tank never varied more than 2°. For the sake of comparing the trend of the temperature in the two types of tanks, table 9 is included giving weekly averages of the temperatures in the

TABLE 8

Temperatures of influent and settled sewage

DATE	INFLUENT	TANK	DATE	INFLUENT	TANK
Feb. 24	47.8	47.7	June 9	62.6	62.6
Mar. 2	47.7	47.7	June 16	64.0	64.4
Mar. 10	46.4	46.5	June 29	65.3	65.3
Mar. 24	48.6	48.2	Oct. 6	67.0	67.0
Apr. 21	52.2	52.0	Oct. 10	67.0	66.9
Apr. 27	53.8	53.8	Oct. 27	61.0	61.0
May 4	56.0	56.0	Nov. 6	60.0	60.2
May 12	56.3	56.3	Nov. 14	60.0	60.0
May 19	57.5	56.8	Nov. 27	57.0	57.2
June 2	60.0	59.9			

TABLE 9

Weekly average temperatures of the separate sludge digestion tank and an Imhoff tank

WEEK	Separate Sludge Tank	Imhoff Tank	WEEK	Separate Sludge Tank	Imhoff Tank
	° F.	° F.		° F.	° F.
Oct. 16-22	67.5	69.5	Jan. 1- 7	55.3	55.5
23-29	65.0	68.0	8-14	54.9	54.0
30-Nov. 5	62.9	67.5	15-21	53.6	53.0
Nov. 6-12	62.6	67.0	22-27	52.0	51.0
13-19	61.0	66.0	28-Feb. 4*		51.0
20-26	59.9	65.0	Feb. 5-11	49.9	50.0
27-Dec. 3	58.1	64.0	12-18	49.3	49.0
Dec. 4-10	57.7	60.5	Heat applied Feb. 22		49.0
11-17	57.6	59.0	26-Mar. 3	52.0	48.0
18-24	56.0	56.0			
25-31	55.9	55.8			

* Therm. out.

separate sludge digestion tank (6 feet below the surface) during 1925-26, and the temperature in the digestion chamber of an Imhoff tank (10 feet below surface) during the same period in 1924-25.

It is of interest to note that, with a properly insulated separate sludge digestion tank, as used in Plainfield, the temperatures during December, January and February were practically identical with the records obtained for the Imhoff tanks during the previous year. Since the incomplete data obtained during this year on the Imhoff tanks never showed a greater variation than 2° F. with the separate sludge digestion tank, it seems fair to conclude that during the winter months the effect of the incoming sewage on the temperature in the digestion chamber of an Imhoff tank is not necessarily favorable. This is to be expected if it is kept in mind that the temperature of the tank contents is governed mainly by the surrounding material of the tank (groundwater, etc.).

The amounts of lime added to the fresh solids and to the contents of the separate sludge digestion tank during the entire period of experimentation are graphically shown in figure 24. The total amount of fresh solids added was 96,300 cubic feet and the total amount of lime necessary to adjust this value of fresh solids and to keep the tank at a pH value of 7.3 was 15,775 pounds. The sludge in the tank present at the beginning of the experiment required some lime, but none was added until the experiment was well under way. The lime added per cubic foot of sludge (5 per cent. solids) was 68 gm., but calculated on the amount of fresh solids added 76 gm. was necessary per cubic foot of sludge. Disregarding the amount of lime added to correct the tank (not necessary if the tank had been at the proper pH value), the amount of lime needed was 71 gm. per cubic foot of sludge. According to our laboratory experiments, when fresh solids were added daily, the amount should have been approximately half the amount applied. Because of the erratic and spasmodic addition of fresh solids, which were frequently more acid than would have been the case when removed every day from the settling tank, several tons of lime were practically wasted. If these same fresh solids had been stored in the settling tank from one to ten days (only a part being removed each day) the amounts of lime necessary would have been at least doubled again. (We have practical operating data showing that at least 150 gm. of lime per cubic foot of sludge might be necessary under such procedure.)

Bacteriological

The total numbers of bacteria and the different groups of organisms as determined by the dilution method were studied in the liquid and sludge portions of the separate sludge digestion tank.

The results are given in figures 27 and 28. The figures for the liquid part of the tank up to October 26 will have to be discarded because it was clearly the scum that was being examined. From this date on to November 13 the total numbers of bacteria show a low average both in the liquid and to a lesser extent in the sludge. The lactose fermenting organisms have a tendency to diminish during this period. The other groups of organisms showed a fairly high average with minor fluctuations. The percentage of methane in the gas increased, whereas CO_2 showed a decline. No fresh solids were being pumped into the tanks during this period.

From November 13 to 27 or 29 the above noted relationship changed radically. The total numbers of bacteria and of lactose fermenting organisms showed a very marked stimulation both in the liquid and the sludge. During this period CO_2 was increasing and methane and total alkalinity decreasing. Undoubtedly a change of the favorable conditions prevailing in the tank in the previous period had taken place. Whether this was due to excessive amounts of fresh solids additions or to the drop in temperature or to the simultaneous operation of the two factors cannot be determined definitely. The significant fact is that when conditions were ideal for digestion as indicated by low CO_2 and high methane and alkalinity, the numbers of total bacteria were at a low level, whereas when the conditions for the digestion were unfavorable as judged by increasing CO_2 and decreasing methane in the gas and decreasing alkalinity, the numbers of total bacteria showed an unusual stimulation accompanied by a high average of lactose fermenting organisms. This is in line with the general idea advanced previously in connection with the Imhoff tank

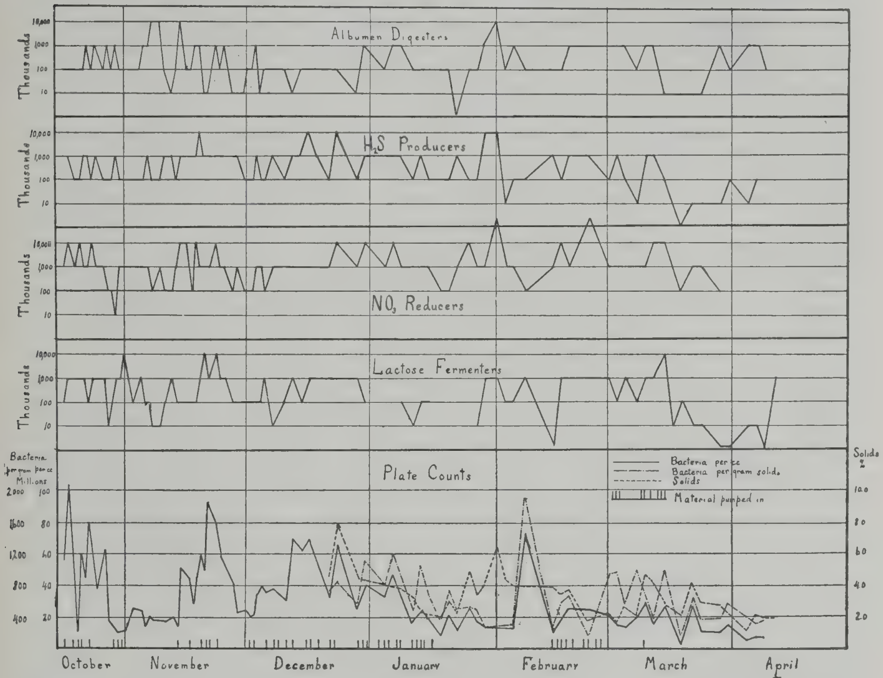


Fig. 27. Bacteria (Plate Count), Albumen Digesters, H_2S Producers, NO_3 Reducers, and Lactose Fermenters in the Liquid of the Separate Sludge Digestion Tank

studies (p. 443), that conditions for favorable digestion are not indicated by high fluctuating numbers of bacteria, but on the contrary, by a low uniform level.

After a short period of rest from November 23 to the end of the month, resulting again in a low bacterial level, the tank was put into operation and received large amounts of solids intermittently up to December 22 with the result that bacterial numbers were high and fluctuated to a certain degree. The gas contained at this time a moderately high percentage of methane and CO_2. It can be deduced from the composition of the gas and the numbers of organisms that the tank was operating in a fairly desirable way, taking care of the solids that were put into it. On December 22 the pumping of fresh solids ceased and on December 24 methane showed a remarkable increase, whereas the bacteria and CO_2 dropped simultaneously. On the twenty-eighth the addition of solids was resumed while at the same time ripe sludge was being withdrawn. During this period the bacteria were maintained at a low level possibly because of the counterbalancing effect of the sludge withdrawn. All this time, lime was being added, alkalinity increased, and the pH value was maintained at or above 7.3. On January 16 the tank was put out of operation

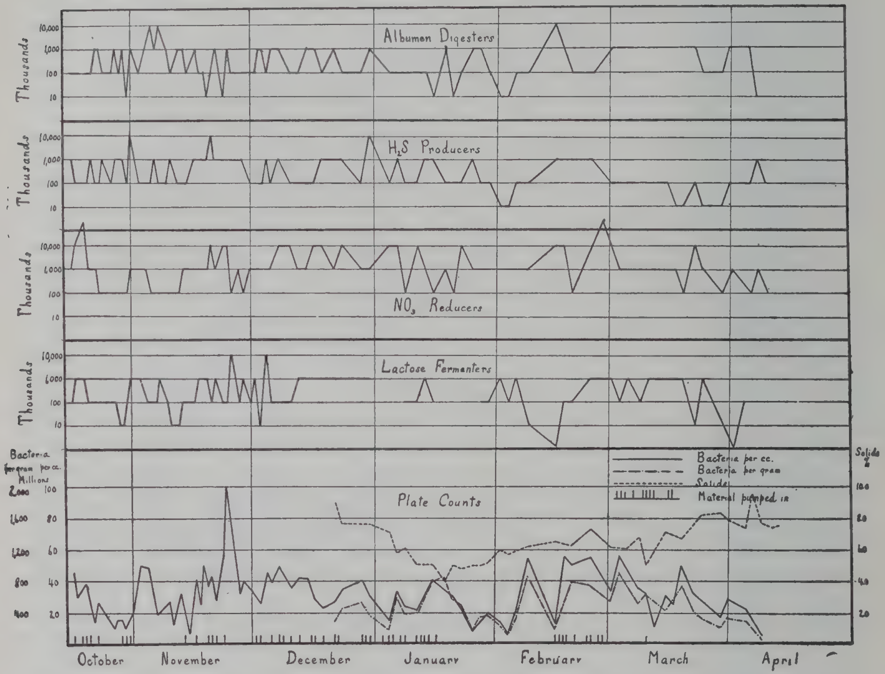


Fig. 28. Bacteria (Plate Counts), Albumen Digesters, H_2S Producers, NO_3 Reducers, and Lactose Fermenters in the Sludge of the Separate Sludge Digestion Tank

for a whole month and a low bacterial level was maintained for the remainder of the period with the exception of a single count on February 8 which must be explained as an experimental error. On February 15 the tank was put into operation again and on the twenty-second heat was applied to the tanks for a short period.

From the above account of the behavior of the tank during 6 months certain features stand out clearly:

1. When the tank is receiving large amounts of solids, and sufficient lime is not added to neutralize the acidity, the numbers of total bacteria and lactose fermenters increase. On the other hand, when the tank is resting the numbers of organisms are at a low level. 2. In an operating or resting tank, desirable digestion is carried on, as indicated by high methane and high alkalinity, by maintaining a uniform and not excessively high level of bacteria.

A word must be said in regard to the organisms that are grouped as albumen digesters, H_2S producers, and NO_3 reducers. No direct correlation between these nor any correlation with the method of operation or the course of digestion could be observed. They are subject to fluctuation, sometimes to a considerable degree, in which case they must be significant in the digestion processes. However, to make any prediction and to correlate these groups with the type and stage of digestion, with the different materials attacked, and with the end products produced, would be impossible under the circumstances and with our present knowledge. A variety of organisms makes up each group; some of which must be very active in digestion at certain periods, whereas others are not and are simply capable of growing when inoculated into the media used. Nor are these groups exclusive of each other, but it is quite possible that a great many of the same organisms are included in these three different groups. It is believed that by splitting them up into groups of closer physiological relationship, the next step will be made toward a better insight into the organisms responsible for the digestion at different stages.

The curves of the total numbers of bacteria calculated on the basis of dry solids, show the same tendency as the ones on a wet basis, even though the numbers of bacteria are not determined by the percentage of solids. There may be an increase in the numbers of bacteria on a wet basis, with a stationary or decreasing percentage of solids and on the other hand a decrease in the numbers of bacteria with increasing percentages of solids. Thus the number of bacteria is not determined by the percentage of solids and hence the total bacteria on a wet basis will give just as accurate a picture as the figures on a dry basis. A comparison of the total numbers of bacteria on a wet and a dry basis in liquid and sludge indicates that, per gram of dry matter, sludge contains less bacteria than the liquid. This is as could be expected, since the number of bacteria is not controlled by the mere percentage of solids but by the supply of available food.

In the discussion above it was noted that the lactose fermenters increase when fresh material is pumped. Figure 29 will show that not all of the lactose fermenters belong to the *B. coli* group. The dotted line indicates the number of organisms that produce gas in plain lactose broth, and the heavy line indicates those organisms only which produce gas from lactose broth in the presence of gentian violet. As is well known this dye will suppress anaerobic spore-forming gas producers. Thus the growth in the lactose-gentian-violet-broth medium can be considered as representing only organisms of the *B. coli* group, whereas that in the plain lactose broth would include the anaerobic spore formers in addition to the colon organisms. An examination of the figures shows that the *B. coli*

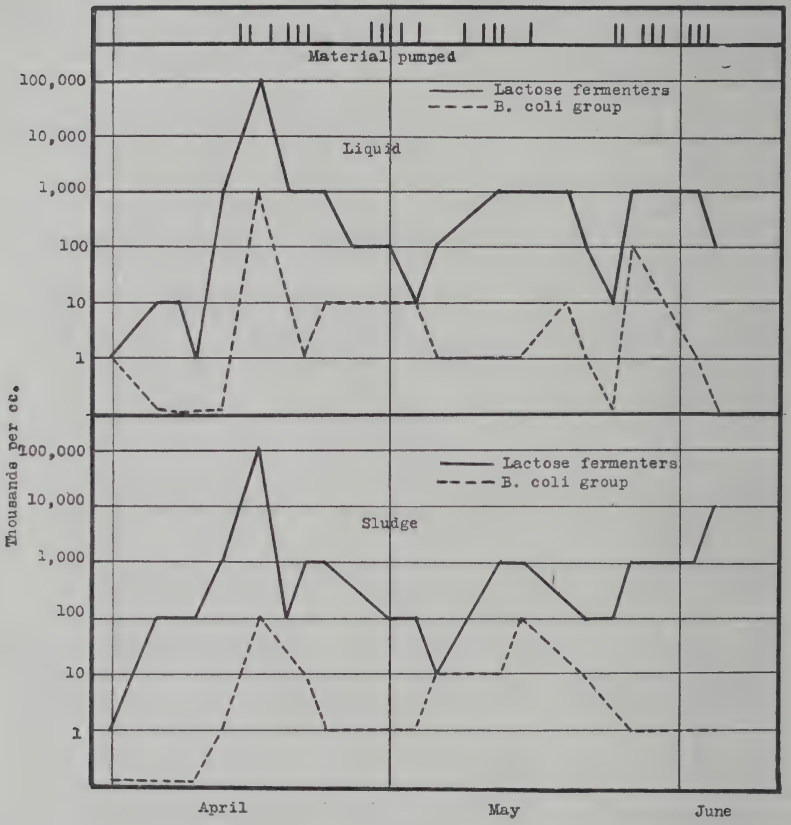


Fig. 29. Comparison of Lactose Fermenters and *B. coli* Group in Liquid and Sludge

group constitutes only a small percentage of the total number of lactose fermenting organisms. Their numbers are restricted when the tank is not operating, and even when fresh material is being added they constitute only a small percentage of the total lactose fermenting organisms. This indicates the importance of spore forming organisms in the digestion processes. In the near future it is hoped that their relative numbers in the different periods of digestion and under different conditions will be demonstrated.

Zoological

The protozoa in both the sludge and liquid of the separate digestion tank were enumerated, three times each week, beginning October 16, 1925, and continuing until April 14, 1926. The protozoan fauna of the separate digestion tank is not so extensive as that of the Imhoff tanks. It appears that separate digestion of sludge restricts the genera found to those protozoa which thrive best under anaerobic conditions and which are sapropelic in their mode of nutrition. A few forms which are known to be holozoic feeders were brought in with the incoming fresh solids but did not remain and multiply in the tank. Some of these were *Lembus, Colpoda, Carchesium,* and *Euglena.* A graphic presentation of the more important organisms is given in figure 30.

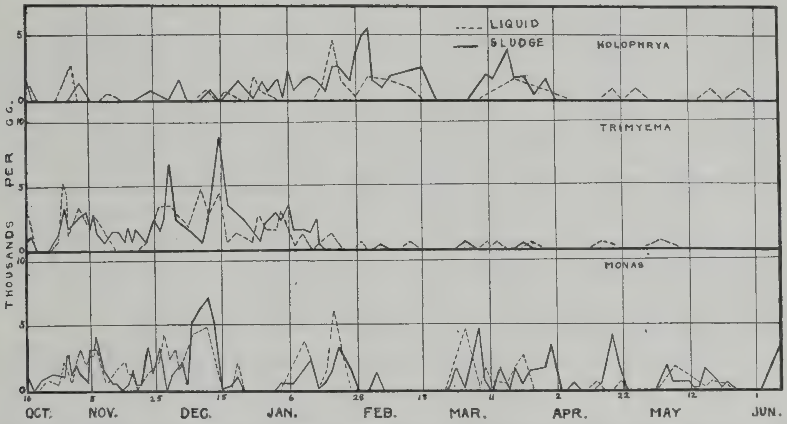


Fig. 30. The Numbers of Two Genera of Ciliates and One Flagellate in the Sludge and Liquid of the Separate Sludge Digestion Tank

The flagellates were the most numerous of the protozoa present. Among the species present, *Trepomonas agilis* predominated and formed the major part of the tank fauna. The total numbers of *Trepomonas agilis* is graphically presented in figure 31 and the total number of all the protozoa present is shown in figure 32. Comparing these two figures, the reader may observe that the high peaks in the counts were due almost solely to the one species, *Trepomonas agilis.* This species is a facultative anaerobe and its nutrition is sapropelic. Lackey (10) has shown that large cultures of *Trepomonas* will thrive in anaerobic conditions, as in Novy anaerobic jars. Four other species which thrived in the separate digestion tank were *Trimyema compressa, Monas amoebina, Holophrya* sp., and *Cyclidium glaucoma.* All these have been made to reproduce abundantly in anaerobic cultures by Lackey (10). *Cyclidium glaucoma* has been cultured in our laboratory under semi-aerobic conditions upon bacteria which lived upon minute amounts of lactic, butyric, and acetic acid added to the tank liquid, in the proportion of 1 : 100,000 and 1 : 10,000.

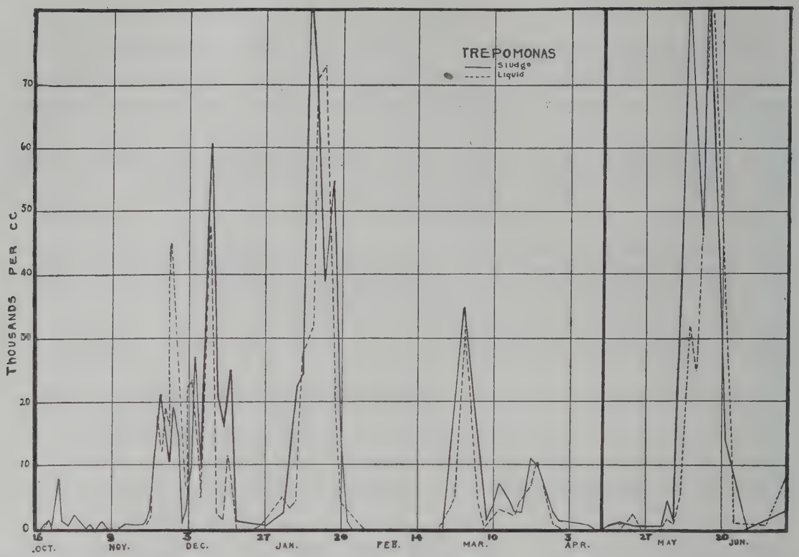


Fig. 31. The Numbers of Trepomonas—the Dominant Flagellate—in the Fauna of the Separate Sludge Digestion Tank

The enumerations showed that the numbers of protozoa in the sludge were slightly higher than in the liquid. This confirms what has been pointed out by Lackey (17) that there is a direct correlation between the distributions of solids and of protozoa.

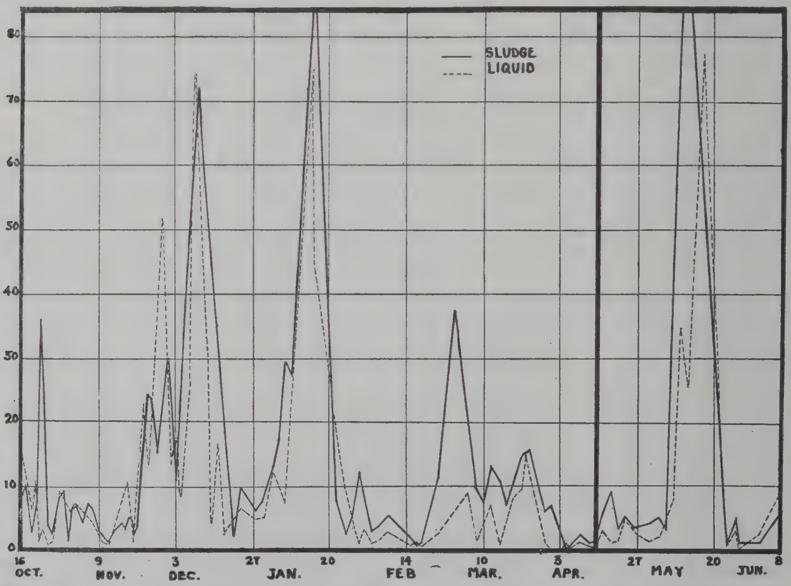


Fig. 32. Total Number of Protozoa in the Liquid and Sludge of the Separate Sludge Digestion Tank

The protozoan fauna in the separate digestion tank rose above 100,000 per cubic centimeter only once from October to April, 1926. On January 13, 1925, 182,000 per cubic centimeter were enumerated in the sludge. Aside from a few peaks, figure 32 indicates that the protozoa remained below 20,000 per cubic centimeter during the greater part of the experiment. The addition of lime to the tank undoubtedly contributed toward the decrease in numbers of protozoa. Laboratory experiments have shown that lime has a lethal effect upon the protozoa. The separate digestion tank contained fewer protozoa per cubic centimeter than operating Imhoff tanks and the genera are fewer and are more restricted to the obligatory or facultative anaerobes, whereas all of the species found in the separate digestion tank have been found in the Imhoff tanks.

Discussion

During a period of 6 months the separate sludge digestion tank with a capacity of 25,000 cubic feet received 96,300 cubic feet fresh solids of approximately 95 per cent. moisture. The average percentage of solids in the liquid during this period was 3.3, whereas the average solids in the sludge was 6.5 per cent. The average ash content of the sludge and liquid was 37.4 per cent. At the beginning of the experiment the percentages of solids and of ash were 7.7 and 39.6 respectively, whereas at the end of the experiment the solids and ash were 7.6 and 40.6 respectively, or practically the same as at the beginning. The fresh solids added during the period of experimentation contained from 22 to 24 per cent. ash. Since the percentage of solids and ash in the tank was the same at the end as at the beginning, all fresh material increased from 25 to 40 per cent. ash, or a percentage increase in ash of 60.0. Experiments conducted in the laboratory with unseeded material show that an ash increase of about 40 per cent. can be expected in 18 weeks and with properly seeded material a similar increase in 8 to 10 weeks. As has been stated, the sludge drawn was as good as the best Imhoff tank sludge obtained at Plainfield.

It is of interest to compare the efficiency of the digestion of sludge in an Imhoff tank and in this covered separate sludge digestion tank. Roughly the covered digestion tank digested satisfactorily 100,000 cubic feet of fresh material of 5 per cent. solids (95 per cent. moisture) content during 180 days in winter at an average temperature of 55.5° F. As the capacity of the tank was 25,000 cubic feet, this seems to represent a turnover of four times, or a digestion period of 45 days. Shrinkage of the material during the digestion period, however, must be taken into account.

The quantity of solids added in total was equivalent to 555 cubic feet per day, or figured on a dry basis, 1,734 pounds per day. In discussing Eddy's paper on the behavior of Imhoff tanks, Downes (6) presented a graph for the calculation of the required sludge capacity in Imhoff tanks from cone glass readings (the solids in the cone were taken at 2 per cent. solids). Calculating the treatment of 555 cubic feet per day of 5 per cent. solids or 1,734 pounds **dry** solids digesting to an end product of 10 per cent. (90 per cent. moisture) sludge, the addition of 2 per cent. dry solids daily would require a capacity of 25,920 cubic feet. Applying Downes graph (assuming that it is applicable to fresh solids at 5 per cent. in the process of digesting, to sludge of 10 per cent. solids, as well as to 2 per cent. solids digesting to sludge of 5 per cent. solids) we find that the 25,000 cubic feet capacity of the tank, equivalent to 45 days' accumulation of sludge (undigested and uncontracted) is on the other hand equivalent to 100 days' accumulation of sludge in the various stages of digestion.

The theoretical advantage of raising the slot of an Imhoff tank so as to increase the effective sludge storage space to 150 days has been shown by Downes (5); applying his theory to one of his tanks he found that even 150 days was insufficient. However, calculations made in our laboratory showed that this tank had received more fresh solids than it could handle. In the discussion of Eddy's paper Downes (6) showed that of the four plants compared by Eddy the two which operated poorly had 55 days (Schenectady) and 80 days (Plainfield) effective sludge capacity up to the slot, whereas the two which were working efficiently had a relative storage capacity of 112 days (Fitchburg) and 200 days (Rochester). On the assumption that at least 100 days sludge storage capacity is required for Imhoff tanks, the covered separate sludge digestion tank did as well as a good working Imhoff tank. This does not necessarily mean that the capacity of the separate sludge digestion tank was reached and that no more could be handled, because: 1. The fresh solids were added to the tank as the need for space arose—a large volume one day, and none the other—rather than the necessary daily additions to keep the correct relation between ripe sludge and fresh solids, or in other words, to hold the biological equilibrium at an optimum, and 2. Downes' calculations were based on summer temperature, whereas the results with the separate sludge digestion tank were obtained during the winter months.

If we assume that the correction of the reaction of the fresh solids by the addition of lime compensated for the higher temperatures in summer, we still find that the separate sludge digestion was as effective as a good working Imhoff tank.

Whether Imhoff tanks or separate sludge digestion tanks are to be used will depend upon the cost (construction and operating) and upon their flexibility and their ease of control. Since we have found that the reaction of the contents of a tank is an important factor in digestion, it appears that this can be controlled with a greater degree of accuracy in separate sludge digestion tanks. The daily addition of definite quantities of fresh solids to ripe sludge is simpler in separate sludge digestion tanks than in Imhoff tanks. Submergence of scum by weighing down and the collection of gases might be equally feasible in both types of tanks. However, it is far easier and more economical to apply heat to a separate sludge digestion tank than to an Imhoff tank.

Amounts of Lime Necessary for Adjustment of Fresh Solids and Material in Digestion Tanks

It was found early in the studies on the effect of lime on digestion, that with the same pH values and different solids concentrations, varying amounts of lime were needed and that with the same concentrations and different pH values, the amounts needed were not always in direct relation to the pH values.

Since the amounts of lime necessary to adjust fresh solids and tank contents varied widely and no data were available for application, a study has been made of the reasons why variations occurred with the object in view of constructing curves which could be used in theoretical studies and practical sewage disposal plant operation.

Method

Fresh solids collected in the usual manner for 24 hours were brought to the laboratory, divided into portions of 100 cubic centimeters, and different quantities of dry hydrated lime added. The mixtures were left standing for about two hours and occasionally thoroughly shaken to insure equilibrium. Total acidity, alkalinity, solids and ash, and pH values were determined at the beginning and the end. Other series were run with the same material but diluted with distilled water to change the concentration of solids. Still other series were run in which $0.1N$ NaOH was added in different quantities to material of different concentrations. In the latter series some were diluted with tank liquid and with fresh solids filtrate.

Results

Material collected at Plainfield for not longer than 24 hours, practically always has a pH value of 6.1.

Examples of actual pH curves obtained by the addition of lime to fresh solids of different concentrations are given in figure 33. It is quite evident that the curves resemble parts of titration curves of more or less strongly buffered substances. The relation between total acidity, alkalinity, and pH values of another series is graphically shown in figure 34. It will be noticed that the initial acidity decreased with the increase of pH values from 5.5 to 6.3 whereas the alkalinity changed but slightly. Evidently most of the organic acids present were rapidly neutralized. It must be kept in mind that total acidity figures are made up of organic acids, amino-acids, acid colloids, etc. Amino-acids and acid colloids are buffers and while greater additions of alkali caused a rise in alkalinity and pH values, total acidity remained nearly constant. A second drop in acidity occurs later with a rise of pH values, whereas the alkalinity curve showed a rise. Finally "total" alkalinity dropped, acidity remained constant, and pH values rose sharply. These changes are even more clearly demonstrated in figure 35. Ordinarily a flattening out of the pH curves occurs around pH 6.2, again at pH 6.7 to 6.8, and again at 7.2 to 7.3 and finally at about 8.2 to 8.4.

At the first point (pH 6.2) organic acids produced in the course of digestion are broken down, at the second (6.6 to 6.8) the organic

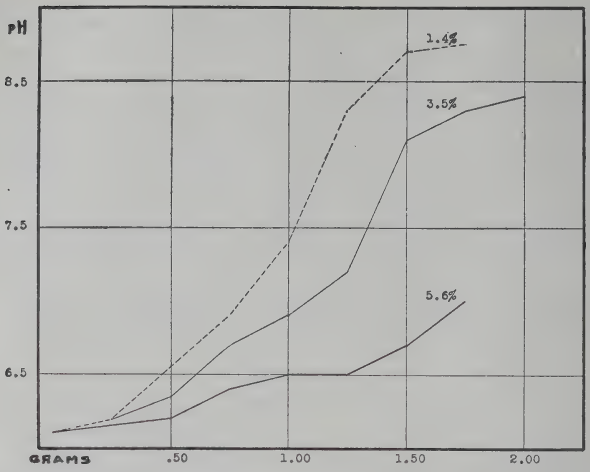


Fig. 33. The Effect of the Addition of Lime on the pH Curve of Fresh Solids of Different Concentrations

acids have practically disappeared and the acidity is due to dissolved CO_2 and acid colloids. The buffer action becomes greatest at this point and rapid production of amino-acids takes place. The third point of action occurs at pH 7.2 to 7.3 due apparently to acid carbonate. If the contention that the buffer action is caused by the different substances as outlined above is true we must be able to show this in a titration curve obtained by adding these organic substances

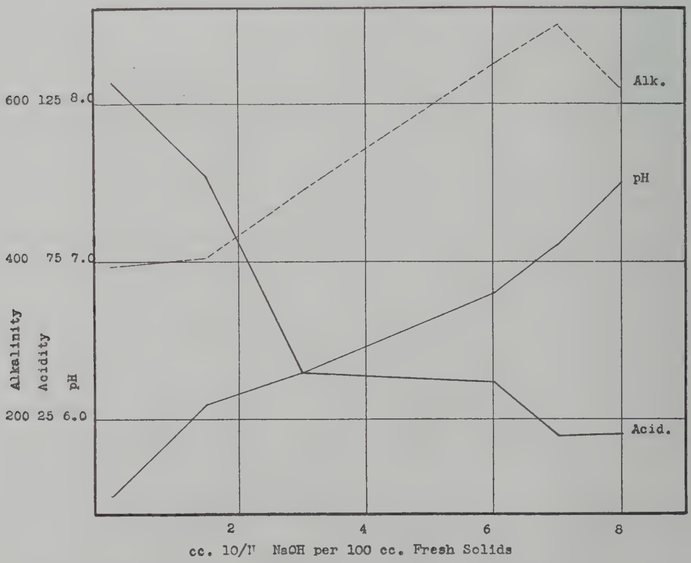


Fig. 34. The Relation Between Acidity, Alkalinity, and pH Values of Fresh Solids (Fresh Solids Concentration 4.5 Per Cent.)

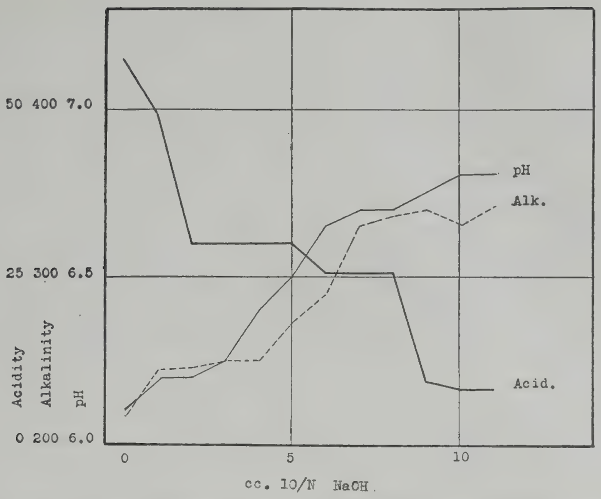


Fig. 35. The Relation Between Acidity, Alkalinity and pH Values of Fresh Solids (Solids Concentration 2.7 Per Cent.)

in solution. Additions of different organic acids, acid colloids, etc., to the decomposing fresh solids would not give a true picture and would upset the "natural" equilibrium. To portions of the same fresh solids were therefore added equivalent amounts of filtrate and also centrifuged material so that the solids become less concentrated but more acid substances were present. Considerably more alkali was necessary to change the pH values at 6.2 and 6.8 with diluted material than with undiluted, in spite of the fact that the percentage solids concentration was only a little over half. (Compare figures 35 and 36.) A study of the character of the material present in the

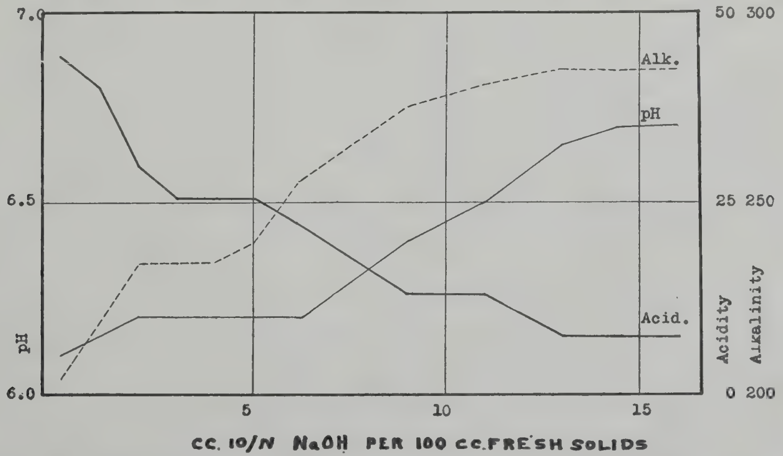


Fig. 36. Effect of Diluting Fresh Solids (2.7 Per Cent.) With Sludge Filtrate to 1.4 Per Cent. Solids on the pH Values of the Material

filtrate shows that at pH 6.2 a large part is in a colloidal stage and a considerable amount of organic acids is present. When such a filtrate is titrated with an alkali, part of the colloidal material is thrown out of suspension. In a case where the course of fresh solids digestion is studied, soluble carbonaceous material is apparently attacked first, followed by protein material and again followed by more resistant carbonaceous material. Pedlow (12) finds that in the first stages of decomposition the rate of disappearance of nitrogenous material from the liquid is greater than the rate of decomposition of protein material in the sludge which supplies the colloidal protein material in the liquid. It would seem thus that at a pH of 6.2 protein colloids are thrown out of suspension, and at the second flattening out of the curve (pH 6.7 to 6.8) carbohydrates are precipitated. This would mean that at least a part of the flattening out of the curves at pH 6.2 and 6.8 is caused by absorption phenomena. In the course of digestion of fresh solids the color and density of the liquid changes around pH 6.2 and again materially just below the neutral point. At pH 6.2 the liquid becomes white opaque, whereas at about 6.8 to 7.0 the yellowish, dense liquid becomes clear.

Table 10

Amount of lime added per liter to the incoming fresh solids and sludge during the entire time (106 days) of the "lime digestion" experiment

pH	7.2			7.6			8.2			8.8		
Solids concentration, per cent	2	3.5	5	2	3.5	5	2	3.5	5	2	3.5	5
Lime added to fresh solids, gm	2.48	4.40	6.15	4.92	8.70	12.80	6.20	10.92	16.42	7.18	12.62	17.17
Lime added to bottles, gm	0.0	0.0	0.0	16.67	21.50	22.66	21.70	41.70	35.90	21.00	26.10	21.20
Total lime in whole period, gm	2.48	4.40	6.15	21.59	30.20	35.40	27.90	52.62	52.32	28.18	38.72	38.37

Since the laboratory experiments have shown that digestion is best and most rapid at pH values of 7.3 to 7.6 it is obvious that the tank contents as well as the incoming fresh material should be adjusted to approximately these figures. The next question is: How much lime should be added? During the entire length of the lime digestion experiment, described in detail in another part of this report (p. 412), the lime added to the incoming fresh solids was almost directly in proportion to the solids concentration (table 10). There was, however, no such relation between the material in the different bottles. Here, the amounts of lime necessary to adjust the reaction were directly related to the total activities. For instance, the amounts of lime added to the bottles of the pH 7.6 series increased from 16.7 gm. per liter with 2 per cent. fresh solids additions to 21.5 gm. per liter with 3.5 per cent. fresh solids additions, but it increased only to 22.7 gm. with 5 per cent. daily additions. In the pH 8.2 series for the 5 per cent. additions actually 6 gm. of lime less than for the 3.5 per cent. additions were necessary. It was found that the amounts of lime necessary to adjust the fresh solids added were directly proportional to the solids concentration and in case the rate of activities in the different bottles kept at the same reactions had been the same the amounts of lime necessary would have been increasd in proportion to the amounts of solids. This was not the case, because the activities of the organisms did not increase at the same rate as the solids concentration. Figure 4 is very enlightening in this respect. As could be expected it may be concluded that the amounts of lime necessary are directly related to the total activities during the course of digestion. It is fair to suppose that each gram of organic matter produces at a given reaction the same kind and amount of intermediate and end products. The greater the amount or the concentration of organic matter the more of these intermediate and end products would be produced, consequently the more lime would be necessary to neutralize the acids and to floc out the acid colloidal material. These contentions were checked up in preliminary experiments and finally long series of laboratory experiments were performed to furnish data for the construction of curves from which at a glance the different amounts of lime at different pH values and at different organic concentrations could be read.

In adjusting the hydrogen-ion value of any sewage material, several factors must be taken into consideration: First, pH value of the sewage to be adjusted to a desired point; second, the amount of total solids and organic matter; and third, the characteristics of the particular sewage under consideration. But inasmuch as the last factor can be largely controlled by a careful consideration of the first two, no further mention need be made.

It is evident, that there are three variables, viz: the ultimate pH value, the amount of solids, and the amount of lime to be added. A curve of the amounts of lime to be added, obtained by direct experimentation, would therefore be in three dimensions. To construct such a curve is impracticable, and to print it impossible; hence the form shown in figure 37 was adopted. From this figure it is apparent that the curve has the form of a pyramid. By cutting a plane section through the pyramid at the point of given concentration of solids and the desired hydrogen-ion value, the amount of lime necessary can be read directly.

In the figure the dotted lines represent the surface of the pyramid and the heavy lines represent the intersection of planes at the given concentrations and desired hydrogen-ion value. It is to be noted that the upper curve gives values for the adjustment of fresh solids only, whereas the lower curve indicates the amount of lime necessary for digestion as well as adjustment. In either case intermediate values either of solids concentration, or of hydrogen-ion values, can be obtained by interpolation. For practical purposes calculations in order

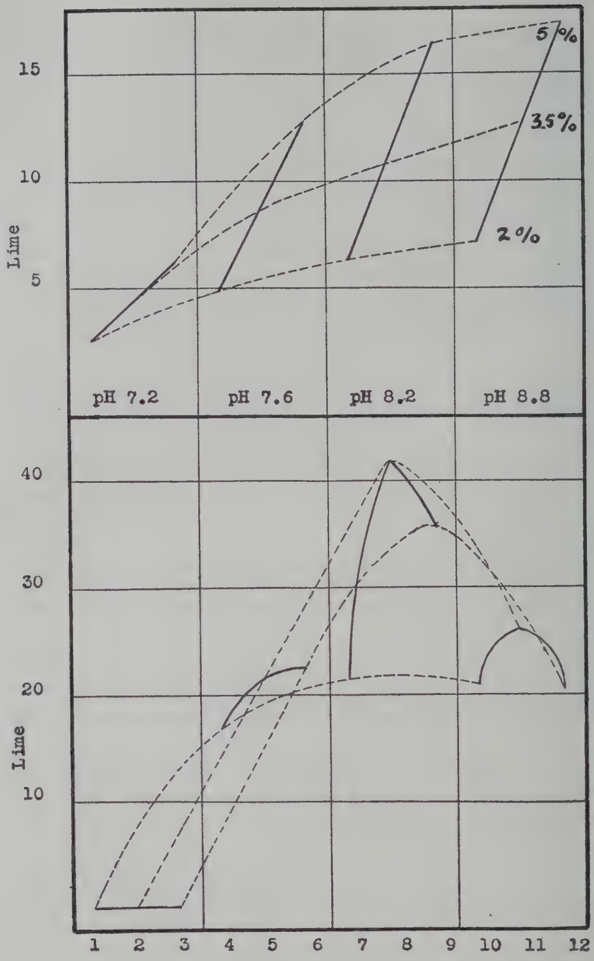


Fig. 37. The Relation Between pH Values, Amounts of Solids, and Amount of Lime to be Added

to find the amount of lime necessary for correction are rather difficult. We have therefore constructed a curve (fig. 38) which shows at a glance the amount of hydrated lime to be added per cubic foot of fresh solids or of partly decomposed matter to adjust the material to a pH value of 7.3. Ordinarily the amount of solids received at a plant is known. The organic matter content of the solids varies only slightly. At Plainfield the variations during the year (analyses for over a year at intervals of 2 or 3 days) were negligible. The organic matter content varied from 74 to 76 per cent. in the settled solids. It seems, therefore, that a few analyses of fresh solids would be sufficient, assuming that the solids concentration is fairly uniform,

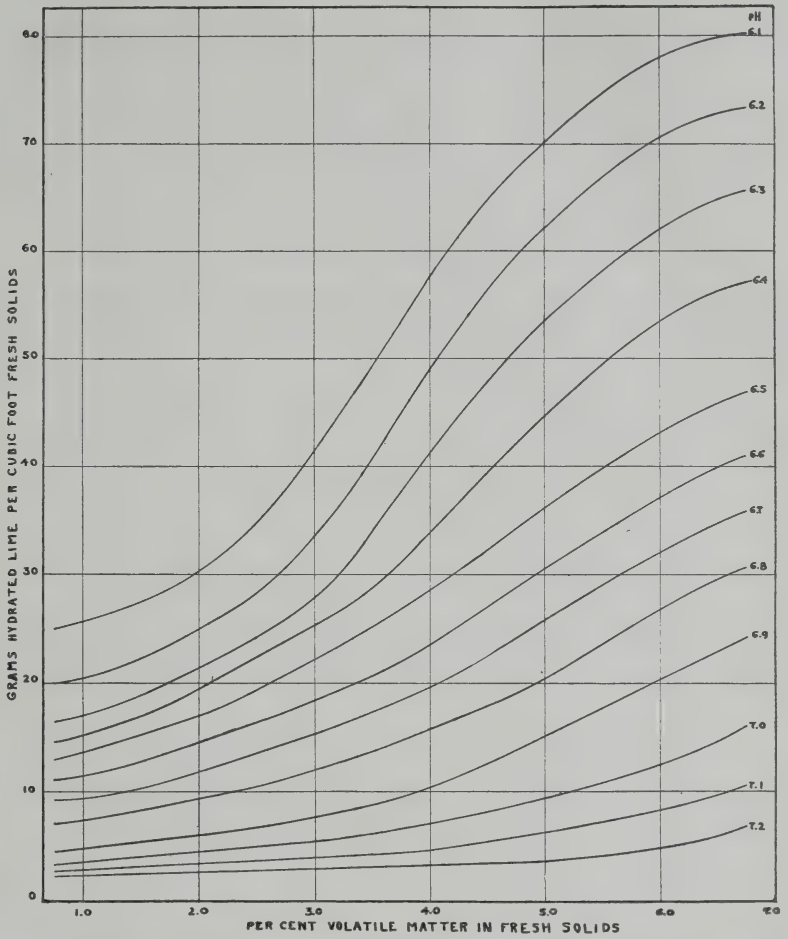


Fig. 38. Amounts of Hydrated Lime Per Cubic Foot of Fresh Solids Necessary to Adjust the Material to a pH Value of 7.3

and all that will be necessary for efficient control is the determination of the pH values.

It will be found that with domestic sewage the amounts of lime to be used for adjustment are small. At Plainfield the sewage is rather stale and has an average pH value of about 7.3. If conditions are well balanced in the tanks the ripe sludge will take care of a definite amount of fresh solids. It is practically impossible, however, to control the rate of additions of fresh solids so strictly that the balance is not upset sooner or later. Moreover, if acid waste materials are added the bacterial action is affected and a depression of the pH values will result. Although the pH determinations of incoming sewage give an idea of how acid or alkaline the incoming material is, they do not give a clue to the amounts of lime needed. As has been pointed out frequently by the authors, the pH of the liquid in the digestion chamber is about the best index of the working of the tank. All our calculations, therefore, are based on the pH values of the liquid. For the Plainfield plant the total amounts of hydrated lime needed to adjust material in the digestion chambers to a pH value of 7.3 are about 3 to 4 pounds per million gallons sewage daily. This is the amount needed after the contents in the digestion compartment have reached this same figure. But what must be done to correct a poorly working, acid, foaming tank? Let us take some examples:

1. A tank is foaming but there is still a distinct sludge, liquid, and scum layer. First we must find approximately how much sludge and scum are present and ascertain their solid concentration.

Capacity digestion chamber	10,000 cubic feet
Sludge (8 per cent. solids)	3,000 cubic feet
Scum (6 per cent. solids)	1,000 cubic feet
Liquid (0.5 per cent. solids)	6,000 cubic feet

(If there are very little solids in the liquid layer they can be disregarded.)

Average solids for chamber	3.3 per cent.
pH	6.8
Lime per cubic foot	10.7 gm.
Total lime for tank	237 pounds

2. An aggravated case of foaming. There is no definite layer of sludge and scum but the solids are distributed throughout the tank. All that is necessary in this case is to determine the solids and the pH value of the material and lime added.

If more accurate determinations are desired it is better to calculate the amount of lime needed on the basis of volatile matter, because the ash contents of different sewages are not alike especially where industrial wastes are received. (Solids—ash=volatile matter.)

It should be borne in mind that additions of lime every day to tanks receiving fresh material are better and more economical than additions of lime at longer intervals. Imhoff tanks kept under daily control can be handled more easily than under weekly control. For separate sludge digestion tanks, solids as fresh as possible should be added daily, and lime additions, if necessary, made at the same time. Constant control of tanks is not only easier and more economical, but insures digestion at an even rate. Separate sludge digestion tanks brought to a pH value of 7.3 will remain there almost indefinitely provided the relation of fresh solids and ripe sludge is correct and the fresh solids added daily are adjusted. If the relation of fresh solids to ripe sludge is correct in Imhoff tanks and the incoming sewage averages about pH 7.5 to 7.6 no lime will be necessary unless sudden changes occur, like additions of quantities of acid trade waste, mash from illicit distilleries, etc. If the average pH values of incoming material are lower, a constant careful control will prevent a good deal of nuisance and expenditure of money.

If a tank is adjusted occasionally, the fluctuations in the reaction of the medium are greater, and consequent biological activities will undergo greater and more rapid changes causing possibly temporary retardation of digestion. It is also possible that under certain conditions, such as high temperatures, digestion will become so rapid that it at first appears as an aggravation of the troubles. These more violent manifestations of activities, whether desired or not, will dishearten the operator or possibly put his plant into a condition from which it will take the tanks some time to recover. The ultimate result will be beneficial, but conditions in the meantime may not be all that is desired.

Methods of Application of Lime

It has been the practice at certain sewage disposal plants to dose the influent to Imhoff tanks with empiric amounts of lime. Sometimes this has given good results while at other times it has aggravated the conditions of the tanks. The reasons are obvious. Additions of lime to the influent are not only wasteful but if the effluent of the tanks is subsequently thrown on filterbeds they might even be harmful, because although part of the lime added will be absorbed by the colloidal material, another part will remain in suspension and be carried to the beds. Biological activities in the filterbeds are, or should be, inherently different from the activities in the tanks. The continuous additions of lime to the beds cause a possible inhibition of the biological activities in the filter and also will cause clogging in the long run. Good results in the correction of an Imhoff tank were obtained by adding dry hydrated lime to the digestion compartment with the aid of a small pump for mixing it with the liquid and scum. Material was pumped out of one compartment into the other and lime added. Although this method of application insured good mixing, it can easily be improved upon. For the correction of a separate sludge tank a similar procedure was followed, whereas adjustment of the settled solids was obtained when they were pumped into the separate sludge tank from the sedimentation tank.

Summary

Figures and curves are presented to show the amounts of lime necessary to adjust the reaction of incoming fresh solids of different concentration. Examples are given for correction of poorly working, acid tanks. The reasons for adjustment are briefly discussed. Lime, if needed, should be added daily to fresh solids going to separate sludge digestion tanks and is preferable also for Imhoff tanks because it is more economical and produces better results. Examples of adjustment and methods of application of lime are given. The amount of lime necessary to adjust the Plainfield fresh sewage solids to pH 7.3 is from 3 to 4 pounds per million gallons sewage daily; to adjust them to a pH value of 7.6, about 25 pounds per million gallons daily.

General Discussion on the Effect of Lime on Sludge Digestion

It has often been questioned whether carefully controlled laboratory experiments would present a real picture of the processes going on in a tank. Still more often it has been questioned whether such experiments could be duplicated on a large scale. Careful observation and analyses have thrown light on the course of the digestion of solids and the fundamental changes taking place. In this way many data have been obtained which confirm experiments made by other investigators, considerable amounts of data of which are not in agreement with other workers, and still more which have enabled us to explain the results obtained by us and others. Finally, the results found in the literature or obtained in our laboratory are checked up and verified. As soon as we have sufficient data the laboratory experiments are amplified and repeated on a large scale in tanks of different design and in tanks subjected to differences in manipulation.

A number of examples could be cited where laboratory experiments and conclusions based on these experiments have been found to hold when subjected to less rigid control in tanks. Attention will be called here to only two of these examples. The first, probably of only academic interest, is in connection with the behavior of Imhoff tanks; and the second, of practical importance, is in connection with digestion tanks of any design. It has been brought out under the bacteriological discussion of the behavior of Imhoff tanks that albumen digesting organisms and H_2S producers increased in the tanks after a certain resting period, also that the albumen digesters preceded the H_2S producers. It has been found in the laboratory that these organisms are most abundant in the second stage of digestion (preponderance of digestion of nitrogenous compounds); and in the tanks it took place after a period of rest when the second stage of decomposition was most pronounced. It seems, therefore, that a resting tank can be compared directly to the material kept in bottles in the laboratory.

It has been pointed out before, that each particle of organic matter flowing into a tank undergoes changes similar to fresh organic material placed in containers in the laboratory or to material placed in a separate sludge digestion tank, but since fresh solids are coming in continuously in an Imhoff tank, particles will be present in all stages of decomposition. The result is that, if the course of digestion of each particle should be plotted and the points of all particles at the same stage of digestion connected, a straight line would result. A series of such connected points for each stage in the digestion processes should give a series of straight lines. When we, therefore, make titrations, pH determinations, etc., of a running tank, we have an indication of the combined stages or activities of a tank and a divergence from the line nearest to the finished product or optimum condition for digestion indicates at once poor working of the tank. A laboratory study, therefore, will be necessary to find basic principles and indications of optimum conditions, but does not necessarily result in finding means for correcting difficulties in an operating plant. If, in addition to the basic principles, measures and means are found to correct improper conditions, experiments must be carried out on a large scale at a plant. This has been done in the case of optimum reaction for most rapid sludge digestion. After it was found in the laboratory that the optimum reaction for sludge digestion was about pH 7.3 to 7.6, experiments were made on a plant scale which seem to bear out the conclusion reached from the laboratory experiments. It is quite possible that there is more than one optimum reaction for sludge digestion when conditions are radically different or modified. We have some evidence indicating this to be the case, but under ordinary circumstances with domestic sewage, or sanitary sewage with comparatively little trade waste, the reaction expressed in pH values as given above is the optimum for sludge digestion (mainly liquefaction).

The maintenance of the optimum reaction in plant operation might seem at first rather difficult, especially in view of the fact that the incoming material, by its production of organic acids and acid colloids, has a decided effect on the reaction of the tank contents. It has been found that with the proper relation of ripe sludge to fresh solids, sufficient alkaline substances are produced by the decomposition to neutralize or counterbalance the effects of the acids. The proper relation between ripe sludge and fresh solids is nothing but the maintenance of the biological equilibrium necessary for most rapid and efficient sludge digestion. If, therefore, a proper biological balance exists in a tank it might not be necessary to add lime for correction, or if the tank contents record a reaction indicating that it is near the "danger line" only sufficient lime need be added to the fresh solids entering the tank to adjust them to the proper hydrogen-ion concentration. It has been found in our laboratory that in the course of digestion several points in the pH curves (figures 34, 35 and 36) indicate strong buffer actions. One of these points comes between pH 7.2 and 7.6. The result will be a material decrease in the danger of adding too much lime.

In former publications (16, 17) we have stressed the point that the proper relation between ripe sludge and fresh solids is as 50:1 on a dry basis, therefore not more than 2 per cent fresh solids should be added daily. But if the reactions of the tanks and of the incoming fresh solids are kept at the proper optimum the amounts of fresh solids added daily can be increased from 2 to 3.5 per cent (dry basis), or the relation of ripe sludge to fresh solids necessary for efficient digestion can be changed from 50:1 to 30:1. This is not only because fresh solids digest more rapidly at the proper reaction, but because the potential acidity produced is taken care of by the lime.

The above statement brings us to a discussion of the "mechanism" of sludge digestion with and without the addition of lime. For a proper understanding of this "mechanism" the following schematic presentation will serve as a basis for discussion.

Incoming organic material is attacked and decomposed in three not sharply divided stages; these stages overlap:

1. Soluble carbohydrates, dissolved nitrogenous material, certain cellulosic materials.
2. Nitrogenous materials.
3. More resistant carbohydrates.

Unseeded fresh material, without lime

I. Period of intensive acid production:

- A. *Materials attacked*
  - a. Easily available carbohydrates (sugars, soluble starches, cellulose).
  - b. Soluble nitrogenous compounds.
- B. *Organisms responsible*
  - 1. *B. coli* group, spore forming anaerobes.
- C. *Characteristics*
  - 1. Increase in acidity.
  - 2. Solids: gray, less than half on top.
  - 3. Odors: putrefactive, H_2S.
  - 4. Liquid: fairly clear to slightly turbid.
  - 5. Slight coagulation of colloidal material with heat and alcohol.
  - 6. Disappearance of protozoa.
  - 7. Increasing B. O. D. values.
- D. *Products*
  - 1. Organic acids, H_2S.
  - 2. Gas: comparatively large volume with high percentage of CO_2 and N_2.
  - 3. Acid carbonates.
- E. *pH range* 6.8-5.1.
- F. *Results*
  - 1. Reduction of colon organisms.
  - 2. Retardation of proteolysis.

II. Period of acid regression or acid digestion:

- A. *Materials attacked*
  - 1. Organic acids.
  - 2. Nitrogenous compounds.
- B. *Organisms responsible* (Not definitely determined.)?
- C. *Characteristics*
  - 1. Prolongation of the low level of pH values followed by a slow rise.
  - 2. Solids: gray to yellowish-brown half to four-fifths at top.
  - 3. Odors: H_2S, indol, onion (mercaptans), etc.
  - 4. Liquid: slightly turbid (milky) to yellow.
  - 5. Some to considerable coagulation of colloidal material with heat and alcohol.
  - 6. High B. O. D. values.
- D. *Products*
  - 1. Gas: small volume, with decreasing percentage of CO_2 and N_2; hydrogen formed.
  - 2. Ammonia compounds (amines, etc.).
  - 3. Acid carbonates.
- E. *pH range* 5.1 to 6.6-6.8.
- F. *Results*
  - 1. Gradual rise of pH curve.
  - 2. Acceleration of digestion.
  - 3. Foaming.

III. Period of intensive digestion of more resistant materials:

- A. *Materials attacked*
  - 1. Nitrogenous materials.
    - a. proteins.
    - b. amino-acids, etc.
  - 2. Ligno-cellulose (?)
  - 3. Fats.
- B. *Organisms responsible* Spore forming anaerobes, and fat splitting organisms.
- C. *Characteristics*
  - 1. Decreased acidity.
  - 2. Increased alkalinity.
  - 3. Slow rising pH curve.
  - 4. Solids: dark brown to black, half to none at top.
  - 5. Odors: odor associated with methane; tarry, rubber.

	6. Liquid: from slightly turbid to clear. 7. Some to no coagulation with heat, slight to no coagulation with alcohol. 8. Reappearance of protozoa. 9. Rapidly decreasing B. O. D. values.
D. *Products*	1. Ammonia and other protein degradation products. 2. Organic acids. 3. Gas: large volume with high percentage of CH_4, low CO_2, and N_2 and no H_2.
E. *pH range*	6.9 to 7.4.
F. *Results*	Sludge stable enough for disposal.

Hardness of water may be a factor in changes of pH values, but the general scheme would be similar. With increased hardness of water the rate of sludge digestion should increase.

The rapid production of ammonia-nitrogen noticed in all our digestion experiments during the first few days indicates that nitrogenous materials are attacked. At the beginning of digestion, nitrate-nitrogen varies from 6 to 10 p.p.m. decreasing to 1 to 2 p.p.m. in a week or 10 days. Albuminoid nitrogen and amino nitrogen on the other hand remain practically stationary during the first 10 to 14 days. This would indicate that the nitrogenous material attacked during the first stage of decomposition is in a soluble form. It is quite possible that the soluble carbohydrates serve as energy for the bacteria belonging to the colon group which use this material to reduce nitrates. The nitrogen gas produced during this first stage therefore would be a by-product and explains the high percentage of this gas present. In addition to the dissolved and soluble materials the true cellulosic materials are decomposed but mainly during the second part of this first stage.

During the period of intensive acid production, organic acids are formed faster than they are broken down, whereas during the second stage of decomposition the acids are broken down faster than they are formed and the accumulated acids decrease. The result is that "total acidity" decreases and pH values begin to rise. The decrease of organic acids makes the medium more and more favorable for proteolysis, amino acids increase, ammonia nitrogen reaches a high peak and from then on begins to fluctuate but remains at a high level. Still later the ammonia compounds make the medium more favorable for the decomposition of more resistant carbohydrates, such as ligno-cellulose, and fatty substances, which give rise in turn to the organic acids. These organic acids, neutralized by alkaline decomposition products or lime, promote the decomposition of nitrogenous materials. As soon as the activities come to an equilibrium, a "biological balance" is established. If this biological balance is not influenced by the sudden addition of large quantities of fresh solids, industrial wastes, etc., but is maintained by a comparatively even food supply (proper daily additions of fresh solids) it will function indefinitely. Such a functioning will be characterized by an even production of gas (high methane content), absence of foaming, even pH values of material (7.3-7.6), comparative absence of odors, and other general indications of efficient digestion, like physical conditions of liquid and sludge (color, drainability, etc.).

The purpose of maintaining this proper reaction of the medium (by the addition of hydrated lime) is to propagate, stimulate, or accelerate the establishment of, or to sustain, this proper biological balance. The addition of lime does not change the course of digestion as outlined above. They continue, but the acids produced are neutralized by the lime as soon as they are formed, thereby decreasing to a fraction the initial long period when acids retard proteolysis. That this conception is correct is shown by the alkalinity curves for our laboratory experiments (p. 413). The total alkalinity does not rise in periods when lime is added, but just the contrary. In the periods where most lime was needed excessive acid production took place. This was particularly true in the bottles adjusted to higher pH values, where alkalinity dropped in spite of the large additions of lime. However, the addition of lime intensifies the activities of organisms digesting carbon compounds with the result that the rate of acid formation is increased. As long as sufficient lime is added to take care of the excessive (potential) acidity, the activities of organisms decomposing nitrogenous compounds will continue or increase at the same rate as the activities of the organisms decomposing carbon compounds.

When lime is added the alkaline nitrogenous products are not, or are only partly used for the neutralization of acids formed in the decomposition processes, therefore the alkaline products will accumulate. This accumulation may possibly change the course of decomposition of nitrogenous compounds. In a forthcoming publication, the question of decomposition of nitrogenous compounds and the possible changes caused by different factors, such as lime, will be discussed more in detail. If it is true that the alkaline nitrogen compounds accumulate through the addition of lime, the biochemical oxygen demand should be greater during certain stages of digestion when lime is added than during the same stages when no lime is present. Hundreds of analyses show this to be precisely the case. As soon as the intermediate nitrogen compounds are broken down further, the biochemical oxygen demand should drop. Our curves show that such a drop occurs at pH values 6.8 to 7.0. [One of a series of curves is published in *Public Works* (19)]. On the other hand, when lime retards the further breaking down of intermediate nitrogen compounds, higher biochemical oxygen demand values are found. This occurs when an excess of lime is added. An excessive addition of lime retards the activities of those organisms which are responsible for the completion of the decomposition of intermediate nitrogen compounds. The retardation is not necessarily apparent in the reduction of total bacteria; the total numbers may be the same or even greater, indicating a "stimulation" of other organisms. When such a "stimulation" takes place and more acids are produced, the pH index will show sharp fluctuations.

When intermediate nitrogen-decomposition products accumulate, the volume and subsequently the apparent intensity of odors should increase. Nitrogenous substances are most rapidly broken down when the pH curve rises from 5.1 to 6.8. The odors are strongest during this period (disregarding whether or not odors are caused by intermediate nitrogen-compounds products containing sulfur) and in case a proper biological balance is not maintained, odors become most pronounced when acidity decreases or when sufficient lime is added to neutralize the acids, but the organisms responsible for further decomposition of these nitrogenous products have not as yet had time to remove the surplus. Anyone who has treated quantities of fresh solids with an overdose of lime for so-called "sterilization" will know that after some time, when decomposition has started (production of acids and partial or total inhibition of further decomposition of nitrogenous intermediate products), odors emanating from such material are foul and intensive.

Aside from neutralizing acids formed and its effect upon the activities of organisms, lime causes a physical change of the medium, especially in the supernatent liquid. Acid colloidal material, partly decomposed or not, is rapidly flocked out. In case of a foaming tank, the floculation of the suspended material by lime, whether due to a change in surface tension (breaking of gas bubbles) or to growth of floc or both, not only improves the functioning of the tank but also increases temporarily its sludge capacity. The flocking out of suspended material with the aid of large dosages of lime can again be hastened by such manipulations as gentle stirring or paddling. However, fresh sludge obtained by such methods must be taken care of by lagooning, by burying, or by other methods, since in due time such sludge will begin to decompose and create nuisances.

For a real understanding of the effect of lime on a foaming tank, it is necessary to discuss more in detail the causes and factors present in foaming. As stated above the addition of lime flocs out the suspended material, or in other words changes the distribution of solids. The change in distribution of the solids is not due to an inherent quality of the lime but to a change in the reaction of the medium. A similar change in distribution can be caused by acids. We have attempted to show that with a change in reaction bacterial activities change. Let us take a concrete example. When the reaction in a tank changes from slightly alkaline (7.3 to 7.6) to slightly acid (6.6 to 6.9) there is an increased movement of solid particles through the liquid. At the same time the production of CO_2 increases by a change in bacterial activities. The movement or dispersion of the suspended material caused by the initial increase in bacterial activities causes the suspended materials to be broken up into smaller particles; this greater dispersion influences in turn again the rate of bacterial activities with subsequent large quantities of organic acids and finally of CO_2. The suspended material is divided into finer particles, and colloidal material increases. Only part of this material is attacked by organisms (unbalanced biological conditions), and the nitrogenous compounds increase making it a favorable medium for certain protozoa. The excretion products of the protozoa (partly CO_2) add to the already increased CO_2 production. The medium becomes gradually more acid and more charged with colloidal material, which is carried to the top by the gas bubbles. The dynamic movement of the colloidal material increases because of the change in reaction and the increased CO_2 production, and more material is brought to the top.

A series of determinations made on the surface tension of the liquid in a foaming tank, a non-foaming tank, and a tank which was near the danger line of foaming showed some interesting results. A series of determinations together with pH values is given in table 11. At the time when the determinations were made, tank 3 was on the danger line, (as indicated by the pH values), but did not foam; tank 4 was apparently in good condition; and tank 5 was foaming. It can be seen from the table that the surface tension of the liquid of the foaming tank was persistently lower than that of the two other tanks. The drawing of sludge from tank 4 seemed to influence perceptibly the surface tension of the liquid.

TABLE 11

Surface Tension of Sewage Influent and Effluent and of the Liquid of Three Different Tanks

Dates	July 18		July 22		July 23		July 25	
	T†	*pH*	*T*†	*pH*	*T*†	*pH*	*T*†	*pH*
Unit influent	60.0	7.1	70.5	7.3	61.0	7.4	67.2	7.2
Liquid tank 3	57.6	7.0	55.5	7.2	57.4	7.4	57.3	7.0
Liquid tank 4	55.1	7.2	53.8	7.3	58.1	7.6	49.0*	7.3
Liquid tank 5	42.7	6.7	48.8	6.9	45.1	7.0	41.4	6.7
Unit effluent	65.2	7.0	67.0	7.1	61.5	7.2	57.0	7.0

* Sludge drawn.
† Tension in degrees cc.

Bancroft[1] states that either an increase or a decrease in surface tension is sufficient to cause foaming in pure suspensions. It would be possible that changes in surface tension alone (as a result of bacterial activities, which in turn are influenced by the reaction) cause foaming in tanks but it seems that two or more factors play a role. There is a close resemblance between froth (dispersion of liquid in liquid) and foam (dispersion of gas in liquid). In the first case the absorption film acts as an emulsifying agent and in the latter the absorption film may surround the gas bubbles in the foam. Soaps in lowering the surface tension concentrate at the interfaces. It is well known that fatty acids (oleic, lactic, etc.) are good frothing agents. In the digestion chamber a number of organic acids, like lactic, butyric, and acetic are found. These acids are produced and accumulate particularly during the first stages of digestion, or are present when a tank is foaming. Keeping in mind that foaming (acid) occurs at a reaction below neutrality when the production of these acids is greatest and that a direct relation exists between the lowering of surface tension and certain fatty acids, we may assume that the presence of organic acids is a factor in foaming.

---

[1] Bancroft, W. D. 1921. Applied Colloid Chemistry. New York.

As far as is known, every essential oil of the vegetable kingdom is a good frothing agent; salt water (ocean) is one mineral-frothing agent, phenol another, and so on. Nearly always when a tank begins to show signs of foaming, the alkalinity of the foam is far greater than either the liquid or the sludge. In a previous report (17) an example of this was given and is hereby partly reprinted for demonstration:

	FOAM	SLUDGE	LIQUID
pH	8.0	6.8	6.8
CO_3 p.p.m.	510	202	184
Acidity p.p.m.	13	17	26
NH_3-N p.p.m.	160	65	43

It can be seen that pH values, carbonates, and ammonia were far higher in the foam than either in the liquid or sludge. Since the frothing agent concentrates at the interfaces, it is possible that under certain circumstances the ammonium carbonates are a factor in foaming.

Before a statement is made about the possible action of lime let us recapitulate the facts stated above. When a tank is foaming we find:

(*a*) Increased production of a specific gas (CO_2); (*b*) increased organic acids; (*c*) lower surface tension; (*d*) more alkaline products in foam than either sludge or liquid (at beginning of foaming).

It has been pointed out above that the addition of lime ultimately causes the direct or indirect production of large quantities of gas. If the rising gas alone was responsible for foaming we should observe this phenomenon most when gas production is greatest. When the total production of gases increases, the relative amounts of CO_2 increase also, and if we assumed that the finely divided material was carried up by the CO_2 bubbles to a larger extent than by CH_4 bubbles (difference in surface tension of the two gases), foaming would still occur when gas production was highest, because at that time the relative quantities of CO_2 produced are greatest.

The addition of lime to digesting material producing organic acids (fatty and mineral) causes their neutralization or the formation of calcium salts and calcium soaps. The change in reaction causes coalescence of the finely divided material and this growth of the floc causes it to settle out. The alkaline materials produced, possibly acting as a frothing agent and carried up into the scum during foaming, remain in solution or suspension near the place of greatest biological activities, neutralize in turn the acids produced, and apparently "stimulate" activities of other groups of organisms by making the medium more favorable for them. Finally the flocking out of finely divided material would tend to change the viscosity of the liquid with a subsequent change in surface tension of the liquid. It would thus appear that the physical action of the lime in a foaming tank, and probably in good working tanks as well, is a highly important factor. In addition we should not lose sight of the chemical action of the hydrated lime on the mineral compounds present, with the decomposition of amines, ammonia and nitrogen gas are liberated, and the ammonia forms with the CO_2, ammonium carbonates. The ammonia is replaced by the lime. The chemical action of the lime on mineral acids, particularly sulfates, and also on acid carbonates will naturally be of importance.

Summarizing the discussion on the effect of lime on digestion we can state that probably several factors are of more or less importance: (*a*) its effect on the activities of microorganisms; (*b*) chemical reactions induced; (*c*) cause of change in physical conditions of digesting material.

The effect on the activities of microorganisms may be: 1. making the medium more favorable for acid producing organisms; 2. inducing the establishment of a predominantly different flora; 3. making the medium less (or more) favorable for protozoa.

Chemically it affects the organic and mineral acids and under certain circumstances favors the liberation of ammonia.

Physically it floculates the finely divided materials (hydrophyllic colloids) changing the viscosity, and affects the surface tension of the liquid.

STUDIES ON FILM ACCUMULATION IN THE SPRINKLING FILTER BED

W. Rudolfs and D. Peterson

The filter bed investigations during the past year have dealt mainly with a study of the accumulation of film upon the stones. The object of the study has been to learn more about the physical nature of the film and the cause of its accumulation and sloughing.

Figures upon the amount of moisture and solid matter and the percentage of organic and ash contents of the solids have been obtained each week. The film of one week's deposit was studied and compared with the film accumulating from one sloughing period to the next, and during the sloughing process.

Methods

The samples of film collected were scraped from tiles in the cabinet, which is pictured in our 1923-24 annual report (16, p. 52). As explained by Lackey (16), this cabinet makes it possible to take film from five tiles for each week in the year. The film on the tiles had been accumulating since the last sloughing period, as is the case with the stones, when samples were collected at definite intervals. The method of obtaining the film samples has been described (15).

Immediately after collection, the wet film was weighed. The water content of the film was evaporated by placing the crucibles containing the film in an electric oven for 4 days. The dry film was then weighed and incinerated, and the organic and ash contents were calculated. The period of sampling extended from July 15, 1925, to June 16, 1926.

Results

The present study showed that the average weekly deposit of wet film upon a tile was approximately 3.5 gm. (fig. 39). The average amount of solid matter in the weekly film deposit was 4 per cent., containing about 18 per cent. ash. The weekly variations in the amount of ash in the solid content ranged from 10 to 25 per cent. The percentages of solid matter and ash in the film showed a slight increase at the 5-foot level over the 3- and 1-foot levels.

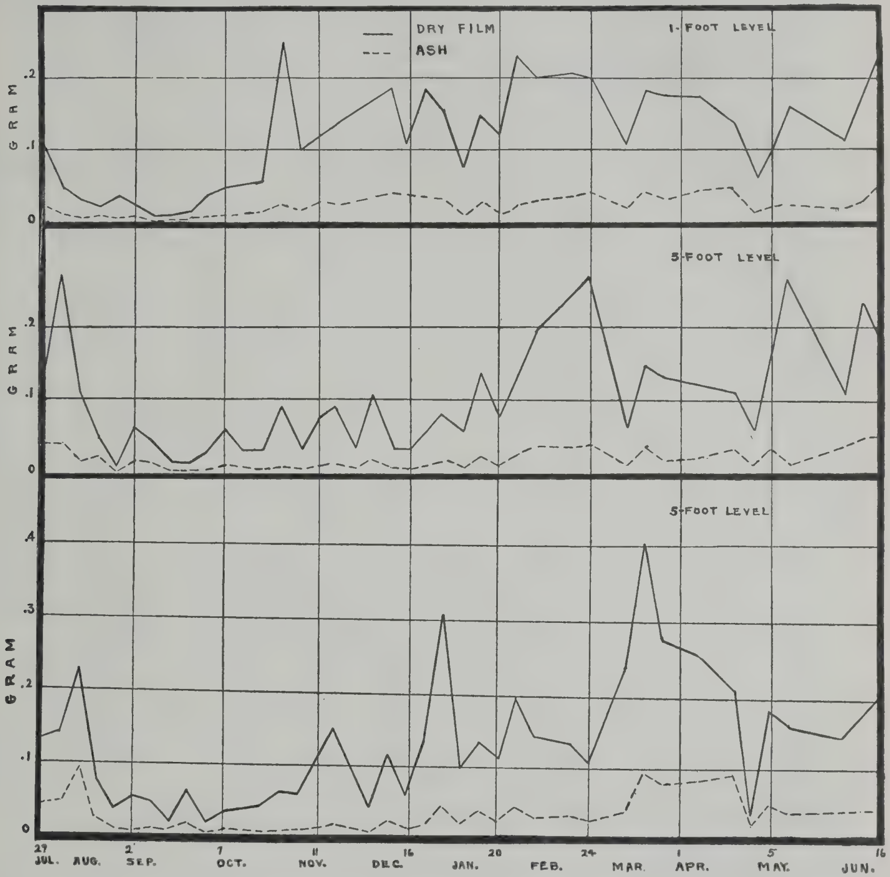


Fig. 39. The Average Weight of Weekly Deposits of Ash and Dry Film When the Film Was Allowed to Accumulate Between Sloughing Periods

The process of film accumulation between the sloughing periods appears to take place in the following manner:

After the film has been removed from the stones, during the sloughing, it begins to build up most rapidly at the surface. The lower levels of the bed then have less film than the upper. As the weight of the film at the upper levels of the bed increases it falls to lower levels. The falling to lower levels may be partly the result of its becoming too bulky and heavy to maintain its own weight and also the result of the washing downwards, by the spray from the sprinkling nozzles. (The effect of animals on film removal is discussed below.)

The final result of this process is that the film becomes heavier at the bottom after a period of accumulation. When the sloughing period has passed, all of the old film is cleared away, and the process of accumulation once more begins to repeat itself.

A comparison of the weights of the solid material of the film deposited at three different levels immediately after the September to October slough of 1925 and preceding the April to May slough of 1926 verifies the above statements. The figures of table 12 and figure 40 indicate the trend.

The film which was allowed to accumulate from 6 to 20 weeks showed in general a slight increase in the ash content of the dry film over the ash content in the film of one week's accumulation. Figure 39 indicates the trend graphically at 1-, 3-, and 5-foot levels. Although fluctuations are apparent, the graph shows that the ash content of the film increased greatly at the lower level until September 23, 1925, when the fall slough commenced. The same trend was apparent in the spring until April 21, 1926. When the sloughing started it began at the upper levels. The film was carried down to the lower part of

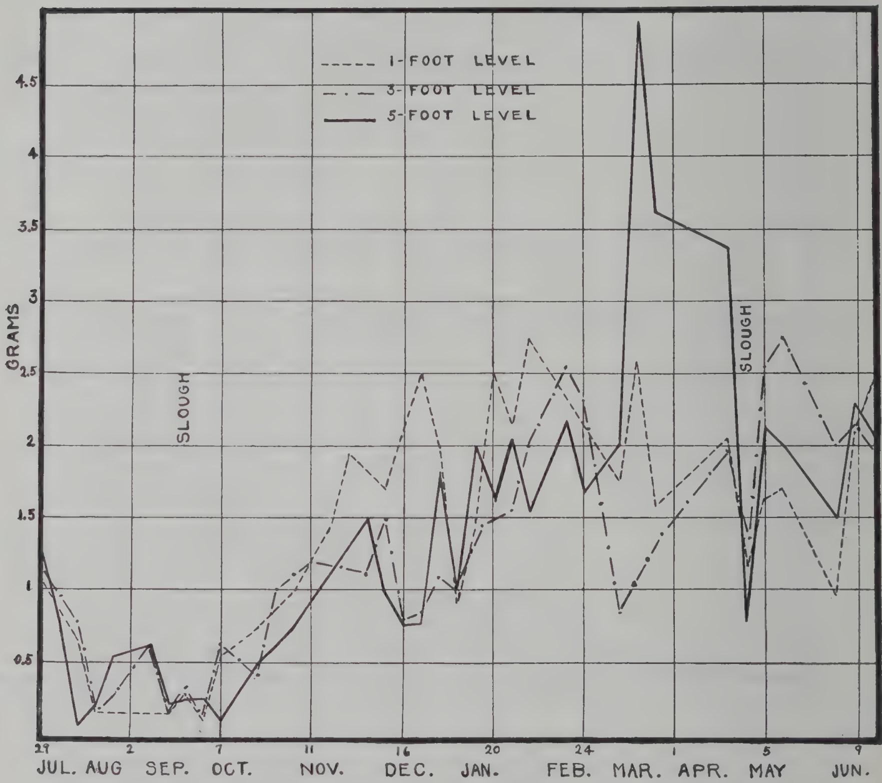


Fig. 40. The Average Weekly Deposit in Grams on Each Tile, Where the Wet Film was Allowed to Accumulate to the Dates Indicated

the bed first and later all the lower deposit passed out with the effluent of the filter bed. The wet film which had accumulated for 14 and 16 weeks weighed from 15 to 50 gm. per tile and contained about 4 per cent. of solids 1 foot below the surface and 6 per cent. at the 5-foot depth. The bulk of such old film may contribute to cause the phenomenon of sloughing.

A weekly census of the organisms of the film was taken from July to December, 1925. They were the same species and approximately the same numbers as have been recorded present in previous years. Figure 40 indicates graphically the fluctuations of the protozoa and metozoa at three levels of the bed. *Opercularia* still remains the dominant protozoan organism in the film. Other protozoa which were numerous were *Aspidisca, Lembus, Chilodon, Lionotus, Paramoecium, Colpoda,* and *Colpidium* among the ciliates; among the rhizopods were *Amobae, Arcella, Euglypha, Trinema,* and *Difflugia.* Exactly the same species dominated as was noted by Lackey in 1925 (17).

TABLE 12

Manner of solid film accumulation between the fall and spring sloughs (film allowed to remain on the tiles)

DATES	DRY FILM		
	1-FOOT LEVEL	3-FOOT LEVEL	5-FOOT LEVEL
	gm.	*gm.*	*gm.*
Oct. 21, 1925	0.40	0.20	0.19
Oct. 28, 1925	1.59	0.45	0.34
Nov. 4, 1925	0.75	0.27	0.40
Dec. 30, 1925	0.97	0.50	1.80
Jan. 13, 1926	1.50	1.40	1.60
Jan. 20, 1926	0.26	0.75	1.10
Feb. 3, 1926	2.10	1.80	1.40
Feb. 24, 1926	1.60	2.00	0.90
Mar. 10, 1926	0.57	1.10	2.30
Mar. 17, 1926	1.80	1.40	4.10
Apr. 21, 1926	1.50	1.30	2.50
Apr. 28, 1926*	1.00	0.76	0.40
May 5, 1926	1.20	1.80	1.82
May 12, 1926	1.50	2.35	1.50
June 2, 1926	1.00	1.30	1.56
June 9, 1926	1.90	2.20	1.80
June 16, 1926	2.70	1.70	1.70

*Slough noticed in effluent.

Discussion

Chemical analyses have shown that nitrification is best shortly after sloughing, and decreases gradually with the increase in thickness of the film (15). Consequently such a large weight of film as accumulates prior to the slough is undesirable. In order to keep the filter bed at its maximum efficiency the film must be kept thin. Studies will be pursued in the future to learn what chemical substances will be of the greatest value in killing off the fauna and flora which obstruct the efficient operation of the filter bed.

If the amount of film accumulation could be kept so as not to exceed that of the weekly deposit on a tile the consistency of the film on the filter bed would not be the same as where it is allowed to accumulate for five months. Lackey (16) has pointed out the difference between one-week-old film which is mainly zooglea and ten-weeks-old film in which he noted three regions, the outer being thin zooglea, the middle a substratum for the outer, and the inner a thin black ooze or mud.

The kind and amount of fauna and flora present on the bed undoubtedly decide to a great extent the rate of accumulation of the film. A large number of living organisms utilizing the colloidal carbon compounds found in the liquid of the spray would necessarily build up the film and increase its solid and ash contents. Materials in solution (carbonates, sulfates) would further tend to increase the film by absorption. A heavy film deposit also tends to become a good receptacle for the ash content found in the colloidal material of the spray.

It has been noted by Lackey (16) that annelid worms, nematodes, and rotifers were more numerous in old film than in film recently deposited. These large organisms necessarily leave more solid excreta than minute and microscopic forms and do not contribute toward oxidation of the spray.

The worms of the bed may be an important factor producing the striking phenomena called "sloughing." If the film were kept constantly thin the seasonal slough would not be such a marked process.

Since the time of sloughing, as pointed out in previous reports, has been hastened in the spring by an early rise of temperature and delayed in the fall by lateness of warm weather, it seems that the slough must be due in part to a change in the flora of the bed caused by the variations of the seasons. The temperature of the season also hastens or delays the development of the ova of the annelid worms and nematodes which are deposited in the film. When the annelid worms appear in enormous numbers they loosen the film and it is easily washed out by the spray from the nozzles. Therefore, the slough, as considered by Crozier and Harris (4) may be intimately connected with the number of annelid worms and nematodes present in the film. The time of sloughing may depend upon their physiology and development; and the loosening of the film upon their writhing habits.

The seasonal slough may be due to more than one factor; it may be the combination of several natural phenomena. The weight of the old film may be one reason, the seasonal succession of fungi a second, and the favorable habitat afforded in the old film for the existence of large metazoan animals a third reason.

It is of interest to consider somewhat more in detail, on the basis of the data obtained, what seems to be happening in the different layers of the filter bed. The purpose of a filter bed is, or should be, oxidation of material in solution and suspension coming from the tanks. The average ash content of film removed every week (new film) between two sloughing periods is low at the top, increases at the 3-foot level and decreases again at the 5-foot level. It has been found in our laboratory[1] that the organic colloidal material coming from the tanks and sprayed on the beds contains from 30 to 40 per cent. ash.

When the film is thin the sewage sprayed on the bed flows through comparatively large channels between the stones, but when the film becomes thick these channels decrease in size. In case the film becomes too thick, clogging of the bed results. The film considered as a retainer of suspended matter could be compared with a sieve. A thin film will be able to retain only a portion of this suspended material and most of it will be washed down to the interior of the bed. The greatest collection of this organic matter is apparently near the 3-foot level, since the ash content is greatest. A smaller portion is washed further down, with the results that the ash content of the film at the 5-foot level decreases again.

The sieve-like action of the film is, however, only part of the story. Aside from organic colloids the sewage thrown on the beds contains soluble materials. These soluble materials are oxidized by bacterial action. Assuming that this soluble material is oxidized fairly uniformly throughout the bed when the film is thin, the procedure outlined above will hold. If, however, as might be assumed with greater accuracy, especially in the light of what follows, the oxidation of soluble material is greatest nearer the top (when a thin film is present) the argument is even stronger because the ash content of the top layer, in spite of this oxidation, is less than at the 3-foot level. A uniform thickness of film throughout the bed might conceivably be compared, at least as far as strainability and possibly as an oxidizing agent are concerned, with a thicker film covering fewer stones. With the gradual building up of the film the amounts of organic matter retained would therefore be increased and its ash content should increase. A comparison of the ash contents of accumulated (old) film with the ash content of film removed every week (new film) shows at once the average ash content in the old film is higher throughout the bed, but especially at the top and at the 5-foot level.

Just after sloughing, when the film is thin, the colloidal material is only partly retained and mostly washed down. When the filter is gradually building up, more and more of this colloidal matter will be deposited in this film, and naturally most of it will be nearest the top. The ash content of the colloidal matter is far higher than that of the film; therefore, the ash content will increase at a faster rate at the top layer than further down. This colloidal material, carrying large numbers of putrefactive organisms, begins to decompose, accompanied by odors. The rate of reduction of this organic matter increases and gradually overbalances the rate of oxidation, which explains part of the findings published in our third annual report (16). As soon as the colloidal material retained by the top layer is partly

---

[1] Unpublished data.

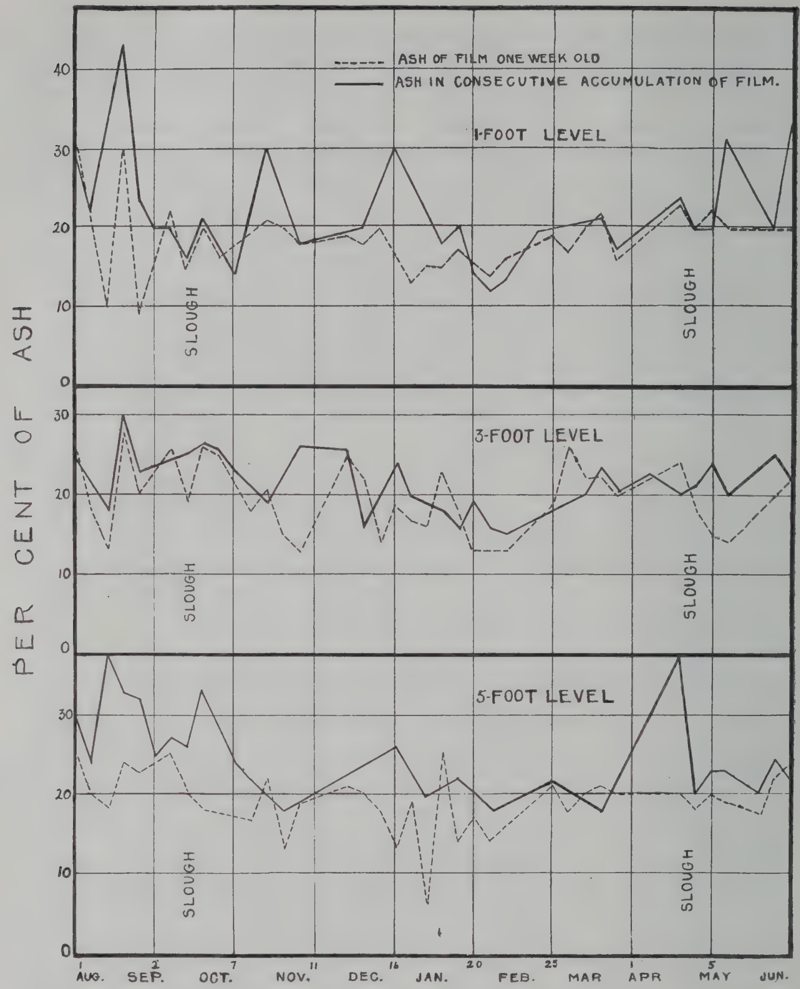


Fig. 41. Comparison of the Variations in the Per Cent. Ash in Film One Week Old and Film Which Was Allowed to Accumulate on the Tiles

decomposed, the decomposition products are washed down by successive sprays, and oxidation sets in. At the 3-foot level, the rate of reduction of organic material is about equal to the rate of oxidation with the result that the average ash content increases in the old film. If this deduction is correct, the ash content of old film at this level should be nearly the same as the ash content of new film. This is actually the case. As soon as the rate of oxidation in the old film is greater than the rate of reduction (5-foot level) the ash content increases again, not only in relation to the 3-foot level, but also in relation to the new film. The result then is that with old film the ash content at the bottom of the bed is caused by oxidation, whereas the ash content at the top is caused by retained colloidal matter from the tanks. If it is kept in mind that the percentage of solids increased with the depth of the bed, it is clear that the data picture the conditions less forcefully than the changes in the bed warrant.

In our 1923 report (15) it was pointed out that the solids are thrown on the bed at a fairly constant rate throughout the year, and that turbidity always decreases most between the 3- and 5-foot levels. The latter fact can be cited as additional evidence for the contention that the chemical reduction of colloidal material at the 3-foot level equals about the oxidation and that the rate of oxidation further down overbalances the rate of reduction.

Since fresh solids deposited from the tanks on the film are not ready for the nitrification process, and since the more rapidly solids are deposited on the bed the less its efficiency, it is clear that the depth of a bed is dependent on the load it is receiving. A thin film around the stones will oxidize the material thrown on the bed more rapidly, on account of the many small channels, or, in other words, on account of large surface area coming in contact with the sewage flowing through. However, if a bed is overloaded a good deal of the colloidal material will pass through the bed into the effluent and will be deposited in the stream receiving the effluent. It is clear, therefore, that artificial means of keeping the film thin around the stones, will result in enhanced oxidation, but such a film will not take care of overloading. It is clear also that the region of greatest oxidation in the bed will depend on the amount of solids to be handled. The above analyses suggest to designers that the depth of a filter bed should depend on the amounts (concentration) of solids to be handled. It will be a question of economics whether more area or more depth is desired. From the Plainfield experiments it would seem that with an average of 75 p.p.m suspended solids to be handled, the beds can not be less than 6 feet deep. However, it is possible that by returning a part of the effluent to the bed, the stability of the effluent can be increased.

Summary

Data collected on old and new film throughout one year showed fluctuations, but there is a general trend. The average amount of wet film deposited upon a tile each week weighed approximately 3.5 gm. with a variation of 2 to 5 per cent. solids (average 4 per cent.). The rate of film deposit was not uniform throughout the bed in regard to total deposit, amount of solids, and percentage of ash.

The older film showed a fluctuating but gradual increase in solids content from one sloughing period until the next, with increasing percentage of ash.

The action and efficiency of new and old film throughout the bed changed according to its accumulation.

It is suggested that the design of a filter bed should depend on the amounts of solids to be handled.

DISTRIBUTION AND SUCCESSION OF PROTOZOA IN IMHOFF TANKS

JAMES B. LACKEY

Introduction

Since the digestion of raw sewage is a biological process, and since Imhoff tanks show a separation of their contents into definite layers or strata, it is worth while, from the viewpoint of the sewage operator, to inquire into the biological conditions in these various strata. Any localization of digestion should involve a corresponding localization of the biological factors involved. Whether the aggregation of these factors is a cause or an effect, may not be answered easily, but it is easily determined, and it may at least prove to be a valuable indicator.

The animal population of Imhoff tanks has been shown to consist almost entirely of protozoa. The most important and most numerous species which have been found so far are described and figured in a prior paper (10). They are apparently to a large extent sapropelic forms, that is, able to live on the dissolved organic matter, without having to take in solid food, but may feed on bacteria to a considerable extent. Now, if the protozoa occur in sufficient numbers, especially the sapropelic forms, they may prove to be of much greater value in the digestive processes than previously has been realized. Although they never approach the numbers of the bacteria (16), their greater size may lend them the importance in comparison which they lack in numbers (11). Certain of the flagellates often group in huge quantities about bits of organic matter and ingest it, in which case they decompose the material and may be an aid in digestion.

This animal population shows considerable variation in the different strata. When a tank has scum, liquid, and sludge layers, the variation is often great. It also varies enormously through periods of time, being greatest when foaming occurs, and smallest when a tank has had a long resting period. In a tank which has no seal of scum the protozoa may even vary to some extent in kind from a tank which is so sealed.

Up to the present there has been no absolute knowledge of any localization of digestion at any point in the tanks. But if it is occurring uniformly throughout the depth, might we not expect a uniform distribution of animals throughout? If there is no such uniform distribution of animals, with what are the maximum and minimum points correlated? Temperature and pH vary but little with depth; and the vertical distribution of organic solids and bacteria is known to a certain extent. Answers to the above questions are sought in the work detailed below.

The greater part of the investigations were carried out at the Plainfield, New Jersey, plant. Work was not confined to any one of the battery of six tanks, but all of them were investigated at one time or another.

A part of the routine work at the sewage investigations laboratory was a weekly or semi-weekly examination of the scum, liquid, and sludge from one of the tanks. But in this work, samples from 3 levels only were taken, and it was soon felt that this was not an accurate picture of the distribution of the protozoa. The only other work done on their distribution was that of Hausman (7), who also studied these levels, and it is necessary to study more levels than the three on which this curve was based.

Accordingly counts were made, for which samples were taken at 1- and 2-foot intervals. Since the population in a tank which was foaming was shown to be quite different from that in one which was not, tanks in both conditions were studied. To obtain a good sample it was necessary to have a self-closing bottle which is described elsewhere (10); with this, and a direct method of counting, a fairly accurate enumeration of the protozoan population is obtainable.

Results

Relative Numbers

There is never any large number of rhizopods in the tanks. The few shelled amoebae are usually found in the sludge, and only rarely are live ones encountered. Small amoebae sometimes occur in fairly large numbers, but these may be amoeboid phases of flagellates.

Flagellates are by far the most numerous. There is not a large variety of them and only a few ever occur in great numbers. Occasionally one species will occur in numbers up to 250,000 per cubic centimeter; at one such time they outnumbered the ciliates by about 80 to 1. Such a high ratio is rather uncommon in the liquid layer, between the scum and the sludge; it is usually lower in the sludge. The ciliates rarely ever reach 20,000 per cubic centimeter. Daily fluctuations are enormous, and under certain conditions a tank may become absolutely barren of protozoan life, as far as is revealed by the ordinary methods of sampling and counting.

Vertical Distribution

No generalization can be made as to the vertical distribution of ciliates, and only a probable one can be made concerning the flagellates. It is seen to vary a great deal and this variation is due, apparently, to the state of the tank. Thus when a tank foams large numbers are carried up into the scum, and an aggregation may occur at the surface. Or if a tank rests for a long period, scum and sludge may become so dense that the protozoa mostly live in the liquid. Figure 43 represents the numbers of flagellates and ciliates per cubic centimeter at the 7-foot level in tank 3, during 22 months. During a part of this time, samples were also taken from the scum, and from the sludge. After plotting the results obtained from these samples, it was found that the fluctuations in the numbers of protozoa from these two levels followed the curve for the 7-foot level almost exactly. There were far fewer animals in the scum than in the liquid, and almost always fewer in the sludge than in the liquid. For these reasons only the distribution in the liquid is given. It must be noted, however, that there were usually more ciliates in the sludge sample than in the liquid sample, as shown by table 13. This has been the case consistently, and for a long time it was assumed that the ciliate population of the sludge was higher than that of the liquid. Basing such an assumption on examinations of only two levels, that is, at 7 feet in the liquid, and at the bottom in the sludge, was felt to be a faulty procedure; therefore, more detailed sampling of the tanks was undertaken at various times. Eleven examinations were made.

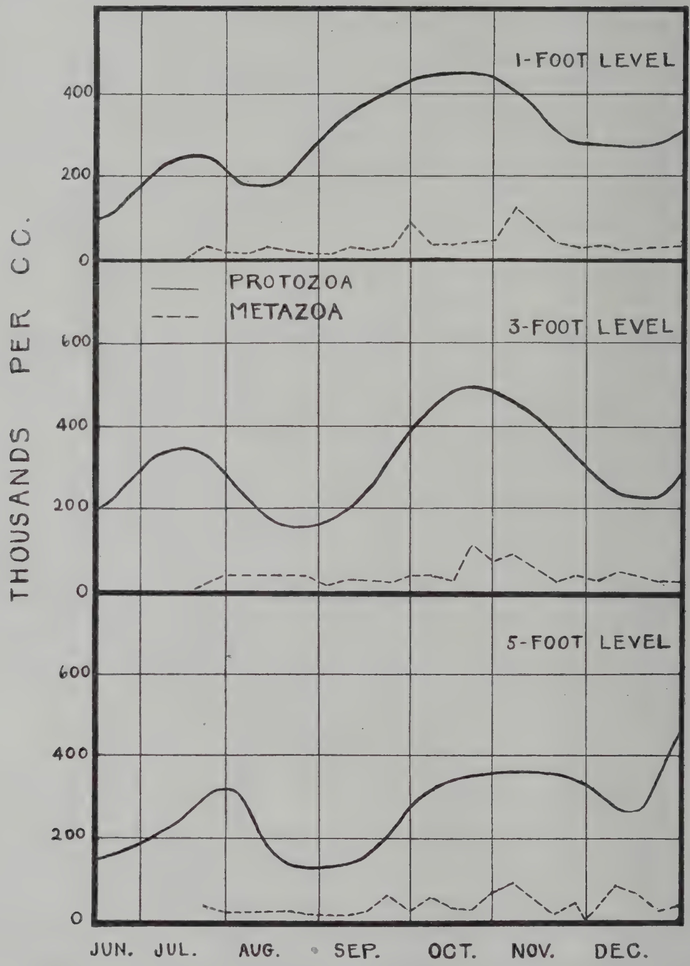


Fig. 42. Moving Average of Protozoa and Metozoa Present in the Filter Beds

The first detailed study of vertical distribution was made between September 12 and October 17, 1923. Samples were taken at somewhat scattered intervals throughout the depth, in tank 2. Figure 44 shows how maximum ciliate and flagellate points move during this

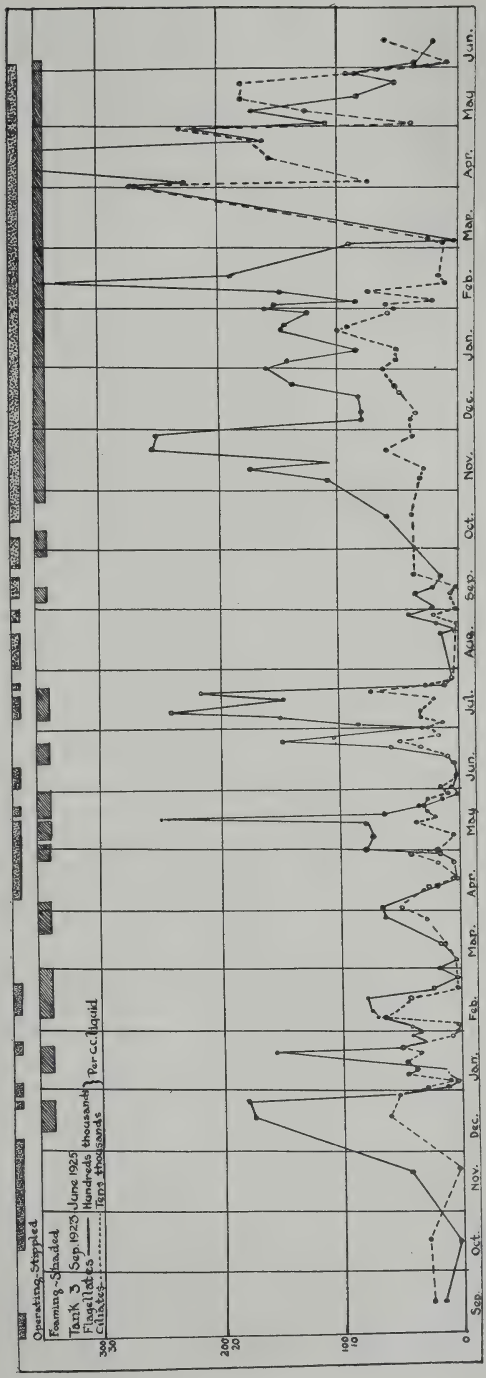


Fig. 43. Occurrence of Flagellates and Ciliates in Tank 3 During 22 Months.
(Note: The scale for the two curves is different)

Table 13

Protozoa present in one cubic centimeter of liquid and sludge

Date	Flagellates		Ciliates	
1924	Liquid	Sludge	Liquid	Sludge
April 12	84000	77000	3400	11400
15	246000	113000	1700	7600
19	67000	50000	2500	10100
22	30000	30000	3000	8500
25	19000	8000	2500	5900
29	2000	800	800	1700
June 30	20000	20000	2500	2500
July 3	88000	25000	1300	8500
7	155000	93000	3000	2500
10	244000	149000	3000	4700
14	148000	73000	2100	6000
17	218000	70000	7600	10800

time. It is thus seen that the peak for the flagellates shifted from the liquid to the scum, whereas that for the ciliates shifted from the liquid to the scum, then to the sludge.

Next, tank 6 was studied. It was first examined on March 25, 1924, when it had been in operation 24 hours, subsequent to a 3 months' rest.

Samples were taken as follows:

Scum at surface
Scum at 1 foot
Liquid at 3 feet
Liquid at 5 feet
Liquid at 7 feet
Liquid at 9 feet
Liquid at 11 feet
Sludge at 13 feet
Sludge at 15 feet

The distribution of protozoa in this tank is shown in figure 45. The numbers of ciliates are comparatively very small, but on a priori grounds one would expect this because of a diminishing food supply. It is not exactly known how the 3 months of rest had affected the bacterial population of the tank, but there must certainly have been a constant diminution of food supply for the sapropelic protozoa. Although the work of Peters (13) and others has shown that bacteria are not necessary as a food for some ciliates, they might be utilized by the forms present here, and their presence or absence should be known, though the small flagellates could have taken their place. This matter, however, will be discussed elsewhere. Then, too, the small amount of available oxygen might have steadily decreased, and unless the protozoa present are true anaerobes, this would have led to a further curtailment of numbers.

From figure 44 it will be seen that the whole ciliate occurrence is in the liquid, and that there is not a great variation in numbers. The maximum, at 11 feet, is about 3 feet above the sludge. Comparing this maximum with the series of studies of September to October (fig. 44), we find that on September 12, the maximum was at 8 feet; on September 17, 6 feet; on September 25 the greatest numbers were in the scum, but the next highest number was at 13 feet. On October 5 the second maximum was in the sludge, and on October 13 and

October 17, the maximum was there, but in the last two cases there was a decided increase just above the sludge. In none of these 6 analyses was there a maximum at 5 feet, where the liquid sample for routine counts are ordinarily taken.

On April 9 the second detailed examination of this tank was made. The tank had been in operation since March 24 and was not functioning normally, as there was no clear liquid. It was almost impossible to tell where the sludge and liquid met. The liquid was neutral (pH 7.0), but there were very few protozoa found. Maximum ciliate occurrence was in the scum; at only two points in the sludge were any recorded—a single Trimyema in each of these two samples.

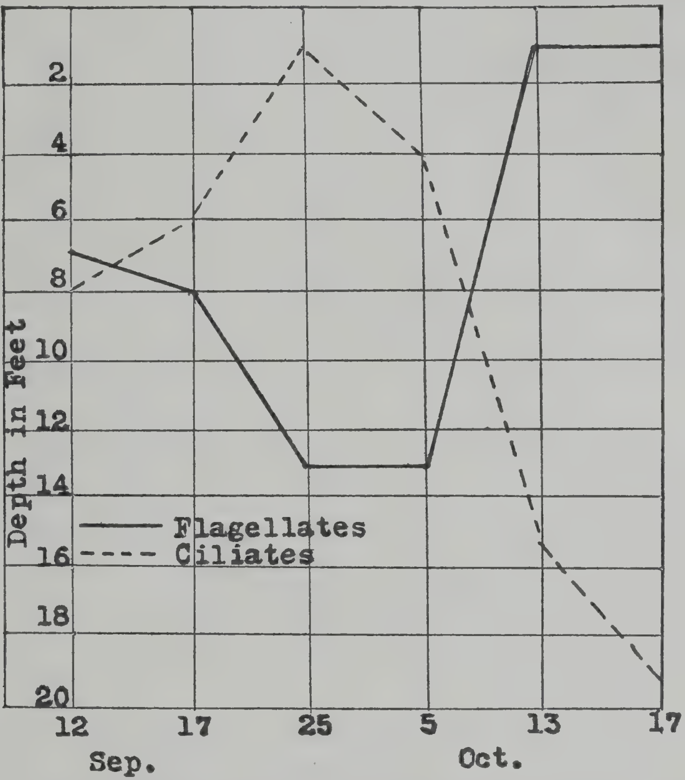


Fig. 44. Points of Maximum Ciliate and Flagellate Occurrence in Tank 2, September 12 to October 17, 1923

On March 20 a similar examination was made of tank 3. This tank was foaming over at the time, and had been thrown out of operation on March 19 after a working period of 26 days. Ciliates were found from the surface to the depth of 17 feet (in the sludge). Numbers were not unusually large, and the maximum—4500—was just under the scum at 5 feet, though this really corresponds to the 3-foot level in tanks not foaming, as there was about 4½ feet of scum here. The second maximum was at 13 feet, just above the sludge, and the third was at the surface of the scum. This last high point is accounted for by the fact that the bubbles of gas carry the organisms to the surface, where they accumulate.

Tank 3 was again studied on April 4 and the maximum ciliate concentration—7400—was in the scum at a depth of 1 foot. Figure 46 shows the distribution of the protozoa. The highest number in the liquid was 4000 and in the sludge was 5300.

Finally, a survey was made of tank 3 on October 28. At this time the tank was foaming badly, the foam pouring into the flow compartment and partly filling it. The scum was thin and viscous. This tank was known to have a fairly large protozoan population at the time, although tank 5, examined the previous day, contained but few protozoa. Because tank 3 was practically a septic tank on this date, there was but little sludge in it, and the protozoan population extended to the bottom apparently, though no samples were obtained between 15 and 22 feet. In this tank there was no maximum at the surface, for the protozoa carried up were dumped into the flow compartment when the scum overflowed. The ciliate peak was at 5 feet, just underneath the scum, and the flagellate peak was at 9 feet. Figure 47 shows the distribution of animals in the tank. It is highly probable that a tank having a sapropelic population as large as this, averaging 40,000 per cubic centimeter, must have its digestion materially affected by protozoa. Attention might be called here to the seeding of the filter beds with protozoa from the tanks. Ordinarily as many protozoa leave a tank as are entering it, but when a tank is foaming, far larger numbers are thrown on the beds. When these organisms find a comparatively thin film on the beds they disappear, but with heavy old film in the process of decomposition, they remain longer.

It will be noted that in none of these five detailed studies was the maximum ciliate occurrence in the sludge; and in only two instances of the six studies from September 12 to October 17 was it in the sludge. Out of all cases then, the maximum occurred six times in the liquid; in the scum three times; and in the sludge twice. It is therefore only possible to say that figure 43 represents the true conditions of ciliate occurrence when a tank is not foaming. The reason for fluctuations in numbers, when the tank is in a more or less unsatisfactory stage, is clearly due to the movement of the solids in the tank (compare conclusion Peterson paper, p. 505), and explains why the maximum ciliates move only occasionally out of the liquid.

One notable exception to this has been in the case of tank 5. After it was put into operation in April, 1924, it quickly developed a fairly large protozoan count. For five or six months the numbers of small flagellates in the sludge were greater than in the liquid. But there were sudden and numerous fluctuations during all of this time. And by October of that year the numbers had decreased in both liquid and sludge, and were more uniform. There were more in the liquid than in the sludge; this remained true as long thereafter as counts were made on this tank. Apparently it did not get to a nor-

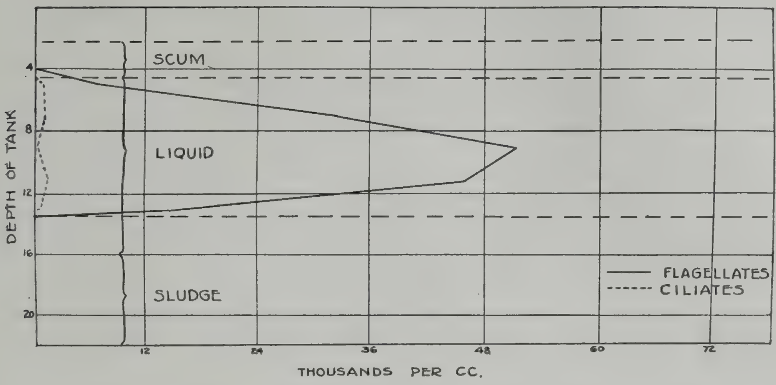


Fig. 45. Distribution of Protozoa in Tank 6, March 25, 1924

mal condition then, for some months, after being reseeded, but when it finally did, the maximum flagellate occurrence was around 7 feet.

It is worth noting that the great increases of flagellate population are in the liquid. Large numbers of flagellates in the scum have so far been associated with foaming, and it is assumed that they are carried up by the gas bubbles, but where a peak occurs in the liquid there are increases in the sludge, and usually in the scum also.

A study of the figures presented will enable us to dispose of the vertical distribution of the flagellates at once. The investigations show that there is a constant tendency to group near the 7-foot level, and that this arrangement is seldom disturbed. There is no absolute uniformity of vertical distribution, as in figure 45, but minor fluctuations occur, as shown in figure 46. These are not so important, and are to be expected. There is possibly no need to attempt an explanation of them. The apparent constant maximum concentration of the flagellates near the 7-foot level, however, is different. It involves a

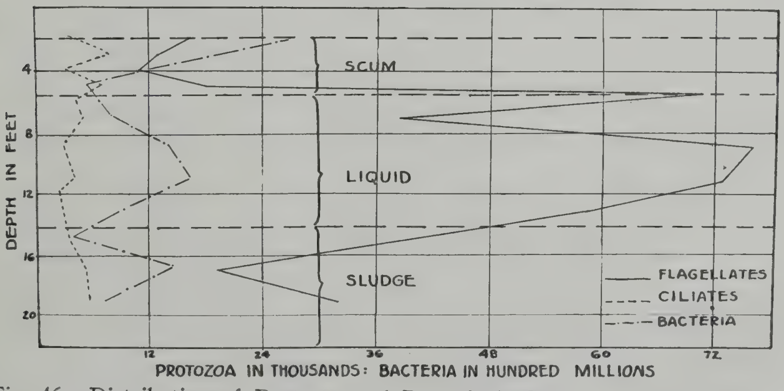


Fig. 46. Distribution of Protozoa and Bacteria in Tank 3, April 4, 1923

detailed consideration of their function in the tanks, and this in turn involves their time distribution.

Monthly Variations in Numbers

For a study of monthly distributions of the tank protozoa, it would be necessary to take into account many factors. The ideal situation would be frequent examinations of a tank that functioned normally for at least a year, the observations to be supplemented by chemical analyses, observations on the type of sewage, records of temperature and pH changes, and so on. The above data are available for the Plainfield plant, but not altogether for a normally functioning tank. Foaming has been a cause of much trouble at this plant, and it has been necessary to take into consideration both periods of foaming and periods of long rest.

Temperature is evidently not a factor to be considered. The tank temperatures vary slowly. Laboratory observations on pure cultures of some of the tank protozoa and on mixed cultures of practically all of them show that under experimental conditions at least, they are independent of a much wider range than the tank temperatures show. Cultures have been kept both at room temperature and in the ice box, and do well in both situations. Days and weeks may pass with little or no temperature changes in the tanks, whereas, as shown by figure 43, a few days suffice to bring about enormous changes in the tank population. No seasonal changes have been evident in mass population, at this plant. Records have been kept for each of the more common ciliates, however, and they seem to show a slight seasonal succession.

Of the ciliates, Holophrya is practically constant in the tanks, though it is perhaps most numerous in the spring months or late winter. Saprodinium has been most abundant in tank 3 in early spring, Trimyema in late fall.

Metopus has become common in tank 3 only within the last year, especially in the spring. But it was for a while the dominant ciliate in tank 5. Tank 3 has had more ciliates this spring than at any time since work was begun, and one of them, *Hexotrichia caudatum,* is new. It may be called a rare ciliate, but in the early summer of 1924 was present in some numbers in tank 5, then disappeared. It has been found again in 1925 in tanks 3, 4, and 5, but its appearance is more apt to be due to other factors than to change of temperature. Data secured so far seem to indicate that there is very little seasonal succession even for individual species. This statement cannot be held true for tanks which are working normally with no foaming, and which show greater extremes of winter and summer temperature.

What, then, are the factors determining the rise and fall, both of mass population and of isolated species? Hydrogen-ion concentration variation has been investigated. Different sewage plants report a wide variance in pH, and there is a natural variation in any tank, from day to day. Following are some of the different pH values, and the corresponding numbers of animals in the liquid in tank 2.

Date	pH	Condition of Tank	Ciliates Per Cubic Centimeter	Flagellates Per Cubic Centimeter
Jan. 19	7.3	Resting	4000	151000
Jan. 28	7.3	Working	600	27000
Feb. 4	7.0	Working	1300	67000
Feb. 28	7.0	Working	400	7000
Feb. 7	6.9	Resting	6700	76000
Mar. 13	6.9	Working	1000	9000
Jan. 14	6.9	Resting		62000
Jan. 17	7.2	Resting		114000
Jan. 19	7.3	Resting		151000
Jan. 21	7.3	Resting		46000
Jan. 24	7.5	Working		23000
Jan. 26	7.7	Working		39000

The above figures appear to indicate that the animal population is independent of the range of changes for the tank. The range is a restricted one and the changes are gradual, admitting of adjustment on the part of the animals. Laboratory experiments on mixed cultures of flagellates, ciliates, and rhizopods have been made, wherein the pH was adjusted in increments of 0.2, between 7.0 and 4.6, using the medium found satisfactory for the growth of these organisms, with citric acid and phosphoric acid to adjust the hydrogen-ion concentration. Some of the organisms quickly died off; others showed a favorable reaction to a pH as low as 6.2. Such a condition might obtain among the varied organisms of the tank, but it appears that hydrogen-ion concentration changes are at best only a contributing factor in the fluctuations. That they are possibly a contributing factor must be kept in mind, however, for when the greatest numbers of animals have been noted in tank 3, the tank was most alkaline. Thus on February 13, 1925, tank 3 had 344,000 per cubic centimeter and the pH was 7.5 (see also effect of lime on digestion, p. 412). A sample of liquid received from Eveleth, Minnesota, had a pH of 7.0 and contained relatively large numbers of small flagellates and ciliates, normal in appearance and of the types peculiar to the Plainfield plant.

Inversely, it may be asked if the protozoa affect the pH of the tanks. There is a slight decrease in alkalinity from the bottom of the tanks upward, and this may easily be due to substances such as CO_2 liberated by these animals, since their numbers likewise show a vertical increase upward.

Food supply may determine both seasonal and vertical distribution. This in turn would be largely determined by working and resting periods. But what is the food of the tank fauna? Many of the animals are saprozoic, but some are holozoic. Most of the flagellates seem to be saprozoic and certainly the ones which are most abundant cannot be seen to ingest, nor do stained specimens show bacteria within their bodies. There is an abundance of dissolved food for the saprozoic forms. Numbers of Metopus may often be seen aggregated about masses of fecal matter, on slides of fresh tank material. But careful and long observation (using a magnification of 690 diameters) has failed to reveal that bacteria or fecal matter are being ingested, and no food vacuoles are formed. Since such masses offer a locus for the aggregation of bacteria, either supposition is tenable. But the presence of large numbers of saprozoic protozoa may be considered a fact. It may be a very significant fact, too, for the sewage operator is interested in those organisms which reduce his fresh solids; in a tank which has rested for a long time and where digestion has proceeded almost to stability, *there is still a large bacterial population, whereas the protozoa are either few or lacking altogether*. The suppositions thus indicated are startling. They point out the need for a knowledge of what groups of bacteria are present in tanks at various times; in a "cycle" of digestion, how a tank might digest which is defaunated with respect to protozoa, and a number of other similar problems (see also lime digestion experiments, p. 412).

Perhaps the primary emphasis here should be laid on the faunal difference between an operating tank and one that is shut off. The one in operation has a distinct fauna, and the longer the tank runs, the larger becomes its fauna. A tank which is shut off quickly loses its fauna and reaches a state of stability. Thus tank 3 has shown a decrease in its fauna *every* time it has been shut off, and an increase in its fauna whenever it was again put in operation. If this were fully carried out, a sufficiently long resting period should completely defaunate a tank. On 6 different occasions tanks have been examined after resting periods of varying lengths and no protozoa were found. A contrast is offered in the case of tank 4 and tank 3 in this respect. On April 20, tank 4 was shut off. The decline of its fauna is shown in figure 48. On October 16, 1924, the fauna of tank 3 was about normal, and it was put into operation after a short resting period. This period of operation was continued and the tank eventually began to foam. The upward trend of its population was at once apparent, and until June, 1925, never subsided, though it fluctuated widely. It has gone as high as 650,000 protozoa per cubic centimeter.

A study of the suspended solids may help here. On September 17, 1923, the solids in tank 2 showed a sudden rise, reaching a maximum on September 25. There was never an enormous increase in protozoa (fig. 44) during the time this tank was studied, the numbers of flagellates and ciliates being low; the maximum total population occurred on September 17 for flagellates and on September 25 for ciliates. On September 17 the solids were greatest in the sludge, next in the scum. The ciliate peak on that date was in the scum. The ciliates feeding on bacteria had an abundant food supply at the time, for the increase in solids meant an increase in bacteria, and so we can assume that an increase in solids should mean an increase in ciliate population, at least. The most detailed analysis of the fresh solids was made for tank 3, on October 28, 1924. As shown in figure 47, the protozoan count follows the distribution of the volatile matter in the tanks, and not necessarily the total solids. Both ciliates and flagellates are most numerous near the point of greatest concentration of volatile matter; this is the customary point for the grouping of the flagellates, and may not be significant for them, whereas it may be for the ciliates. No bacterial counts are available for this study.

On April 9, the peak for ciliates coincided with the peaks for bacteria and for solids, in tank 6. The ciliate peak coincided with the bacterial peak in tank 3 on April 4, as shown in figure 46, but the distribution of the solids is not known for this date.

The flagellates, then, are apparently independent of these factors, whereas the ciliates are apparently dependent on the two to some extent. Grouping of the bacteria around solid particles is normal, but to prove that the ciliates are eating either bacteria or solids is quite another matter. Shutting off a tank at once tends to localize the solids in sludge and scum, and starts a decrease in the amount of volatile matter. The flagellates do not follow the bacterial counts, but they do follow the working and resting periods of a tank very closely, increasing when a tank works, but not decreasing when the tank is shut off, as soon as do the ciliates. For the ciliates, a working period starts an increase at once, but a resting period of more than four days is sufficient to cause a decrease in their numbers.

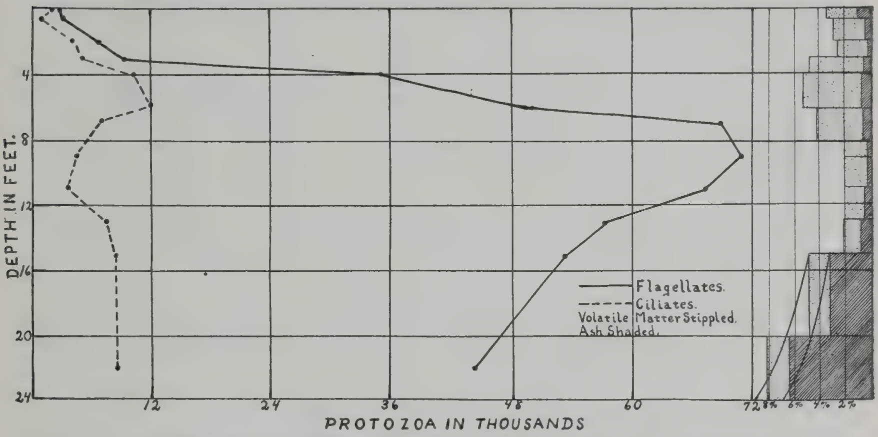


Fig. 47. Distribution of Protozoa and of Solids in Tank 3, October 28, 1924 (Solids, Ash, and Volatile Matter in Percentages on Wet Basis)

Since the bacteria never disappear from a tank, it may be argued that shutting off the tank shuts off a non-bacterial food supply and is responsible for the decrease of protozoa. Tank 4 was shut off for a period of several months at one time; its protozoa quickly died out, although 6 weeks after shutting off the tank, bacteria of a rod type were so numerous "as to give the impression of looking at a centrifuged mass of them." And while there were, therefore, easily enough bacteria for food, they may not have been of the proper kinds, since it has been demonstrated that certain strains of bacteria apparently serve as food for ciliates, whereas others are not used (14). The continual presence of bacteria, however, and the fact that many of the tank protozoa are known saprozoic forms, is a strong indication that the invariable decrease of protozoa attendant on shutting off a tank is due to shutting off the food supply. Some of the flagellates are known to be saprozoic forms (inhabiting the lower part of the human digestive tract), and this would certainly be true for them (8). The saprozoic forms, if present in large numbers, would quickly use up available food; even if present in small numbers, they subsist on food of such a nature that it would not long remain available in a tank.

It was at one time thought that lack of oxygen might be responsible for the decline in numbers of protozoa. The history of tank 4 (fig. 48) was cited as possible evidence, but it has been proved that any tank, resting or working, has a very low percentage of dissolved oxygen. Cole (3) and Juday (9) have shown that small amounts of oxygen are available from other sources, and that many protozoa live in oxygen-free waters. Furthermore, tank protozoa, for the most part, can only be carried as laboratory cultures in Novy or Smillie jars from which the air is exhausted, although this air is usually replaced by H_2S or CO_2, either generated within the jar by the living organisms or introduced. Lack of oxygen, therefore, becomes a necessity rather than a limiting factor.

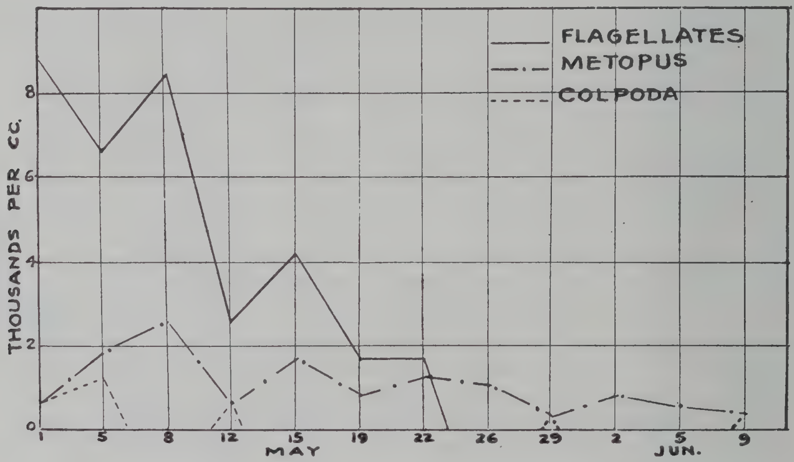


Fig. 48. Behavior of Protozoa in Tank 4 When It Was Set Aside for Sludge Storage

Now and then the numbers of protozoa show sharp increases or decreases, independently of foaming or shutting down. These are due to some deviation in the nature of the sewage. They usually adjust themselves quickly unless the disturbing factor in the sewage remains. Sewage receiving industrial wastes is very susceptible to such fluctuations, and if there is enough of such wastes, the tanks may be altogether lacking in a fauna. Because Imhoff tanks depend on biological processes, effects of trade wastes on protozoa and bacteria should be investigated before a town permits emptying of such material into its sewage disposal plant.

We have, then, in each of the strata of the tanks, two groups of protozoa, the flagellates and the ciliates, whose increases and decreases follow each other closely. It is seen that there is no fixed point about which the ciliates group themselves, and it appears that they are dependent on the localization of the fresh solids and the bacteria, one or both of which they utilize as food. The flagellates constantly group about the 7-foot level, and apparently utilize as food dissolved organic matter in the raw incoming sewage. No reason for the grouping at the 7-foot level can be assigned, unless it be a mechanical one, dependent on the structure of the tanks, this being the point where the narrowest part of the vent begins.

That the protozoa represent a fixed group, seems evident from studies at Plainfield and from samples obtained from other sources. When tank 5 was put in operation after remodeling, it necessarily received a diverse fauna. As the tank gradually became normal; i. e., lost its oxygen and separated into scum, liquid, and sludge, certain protozoa succeeded each other in dominance of numbers. The population of this tank was later confined mainly to the common tank ciliates and flagellates.

Other tanks throughout the country seem to have practically the same population. Occasional changes occur. In tank 3, Heteronema has appeared in numbers at times, but each time, after reaching large numbers, has apparently died out. Oxytrichia has done the same thing and Hexotrichia is even more conspicuous in this regard. But these forms do not find the environment quite suitable and hence pass out.

What, then, are the significant points with regard to the protozoa? Their correlation with foaming has previously been pointed out (11). If bacteria can take care of only a certain amount of material in the tanks without disturbing the biological balance, i. e., if there is a numerical relation between the bacterial maximum and the amount of sewage, the protozoa begin to function beyond this point. The bacteria may be able to digest a certain amount of sewage, and an increase in this amount means larger numbers of protozoa, but it also means an overloaded tank, and hence foaming. They digest sewage, evidently, but they cannot stop the foaming; or in digesting the overload, they add to the tank products which cause foaming. In either case, they mark a danger point for the tank, and if their increase be noted, the tank should be shut off, or, better, corrected with lime.

Summary and Conclusions

1. Flagellates are far more numerous than ciliates in Imhoff tanks.
2. Vertically, flagellates are present in maximum numbers usually between 5 and 7 feet.
3. There is no definitely located point for the ciliate maximum; it varies greatly.
4. There is as yet no proof of a well-defined seasonal succession for any of the protozoa.
5. Tanks which are not foaming have relatively small protozoan populations.

6. The numbers of protozoa decrease to the point of defaunation in tanks which are shut off; conversely, they increase enormously if a tank runs indefinitely.

7. Their numbers are independent of the observed ranges of H-ion concentration and temperature in the tanks.

8. They are largely sapropelic forms, so a continuously running tank offers a constant food supply for them.

9. There is an absolute correlation between large increases in their numbers and foaming.

10. No definite explanation is at hand for the part they play in foaming.

References

(1) Bach, H., and Sierp, D. J. 1925. Laboratoriums versuche über den anaeroben Abbau des Klärschlammes. *Gesundheits-ingenieur* 48: 642-647.

(2) Calkins, G. N. 1926. The Biology of the Protozoa. Philadelphia.

(3) Cole, Arch E. 1921. Oxygen supply of certain animals living in water containing no dissolved oxygen. *Amer. Jour. Physiol.* 33: 1-35.

(4) Crozier, W. J., and Harris, E. S. 1923. Animal population of a sewage sprinkling filter. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1922: 503-506.

(5) Downes, J. R. 1923. Notes on the proper placing of the slots in Imhoff tanks. *Pub. Works* 54: 363-365.

(6) Eddy, H. P. 1925. Imhoff tanks—Reasons for differences in behavior. *Trans. Amer. Soc. Civ. Engin.* 58: 465-510.

(7) Hausman, L. A. 1923. Preliminary studies on the fauna of the Imhoff tank. *Amer. Jour. Pub. Health* 13: 656-658.

(8) Hegner, A. W., and Taliaferro, W. H. 1924. Human protozoology. New York.

(9) Juday, C. 1919. A fresh-water anaerobic ciliate. *Biol. Bul.* 36: 92-95.

(10) Lackey, J. B. 1925. Studies on the biology of sewage disposal: The fauna of Imhoff Tanks. N. J. Agr. Exp. Sta. Bul. 417.

(11) Lackey, J. B. 1925. Are Microscopic Animals a Factor in the Foaming of Imhoff Tank? *Pub. Works* 56: 344-345.

(12) Pedlow, J. T. 1926. The material suspended in the liquid above decomposing sewage sludge. Thesis, Rutgers University.

(13) Peters, R. A. 1921. The substances needed for the growth of a pure culture of Colpidium colpoda. *Jour. Physiol.* 55: 1-32.

(14) Phillips, Ruth L. 1922. Growth of Paramoecium in infusions of known bacterial content. *Jour. Exp. Zool.* 36: 135-184.

(15) Rudolfs, Willem, et al. 1923. Studies on the biology of sewage disposal. N. J. Agr. Exp. Sta. Bul. 390.

(16) Rudolfs, Willem, et al. 1924. Studies on the biology of sewage disposal. N. J. Agr. Exp. Sta. Bul. 403.

(17) Rudolfs, Willem, et al. 1925. Studies on the biology of sewage disposal. N. J. Agr. Exp. Sta. Bul. 427.

(18) Rudolfs, W., Heukelekian, H., and Zeller, P. J. A. 1926. The relation between ripe sludge and incoming fresh solids. *Amer. Jour. Pub. Health* 16: 765-768.

(19) Rudolfs, W., and Fischer, A. J. 1926. Ripe sewage sludge. *Public Works* 57: 171-173.

(20) Ternetz, C. 1912. Beiträge zur Morphologie und Physiologie von *Euglena gracilis*, Klebs. *Jahrb. Wiss. Bot.* 51: 443-514.

(21) Zeimstein, H. 1900. Zur Morphologie und Physiologie der *Euglena gracilis* Klebs. *Prings. Jahrb.* 34: 149-198.

Report of the Department of Soil Chemistry and Bacteriology

Jacob G. Lipman
Augustine W. Blair

THE AVAILABILITY OF NITROGEN IN NITRATE OF SODA, AMMONIUM SULFATE, AND DRIED BLOOD WITH VARYING RATIOS OF PHOSPHORIC ACID AND POTASH

Season 1925

The work here reported was started in 1922. Reports for the years 1922 to 1924 have already appeared (1, 2, 3), but for convenience a brief statement of the plan of the experiment as reported in the work for 1924 is included here.

Plan of Experiment

Sixty soil cylinders, of the type that has been in use at this station for a number of years, arranged in two sets of 30 each, were filled with topsoil to the depth of about 10 inches and treated with nitrogenous fertilizers according to the plan given below.

As will be noted the cylinders are arranged in pairs, there being three pairs for each nitrogen treatment. This arrangement provides for three different amounts of phosphoric acid, in the ratio of 1:2:3, according to the diagram. The potash treatment is uniform for the entire set of 30 cylinders. The second set of 30 cylinders differs from the first in that the amount of potash is double that used in the first set.

Plan of experiment

Source of Nitrogen	Single Portion P_2O_5	Double Portion P_2O_5	Triple Portion P_2O_5
No nitrogen (check)	(x) (x)	(x) (x)	(x) (x)
Nitrate of soda	(x) (x)	(x) (x)	(x) (x)
Ammonium sulfate	(x) (x)	(x) (x)	(x) (x)
Dried blood	(x) (x)	(x) (x)	(x) (x)
⅓ nitrogen from each	(x) (x)	(x) (x)	(x) (x)

The actual amounts of fertilizers used per cylinder were as follows:

Nitrogen—10 gm. of c.p. nitrate of soda and equivalent amounts of the other materials.

Phosphoric acid—10, 20 and 30 gm. of 16 per cent. acid phosphate.

Potash—2.1 and 4.2 gm. of c.p. potassium chloride.

Lime—used in the form of ground limestone to bring the reaction to about pH 6.6 to 7.0.

For the check cylinders, then, the relative amounts of the fertilizing constituents would be as shown in table 1 and for the nitrogen treated cylinders as in table 2.

TABLE 1

Relative amounts of fertilizing constituents for the check cylinders

N	P_2O_5	K_2O
0	5	4 and 8
0	10	4 and 8
0	15	4 and 8

TABLE 2

Relative amounts of fertilizing constituents for the nitrogen-treated cylinders

N	P_2O_5	K_2O
5	5	4 and 8
5	10	4 and 8
5	15	4 and 8

The soil used is a silt loam which was distinctly acid in the beginning but which was corrected by the use of ground limestone, as already mentioned. The cylinders have a surface area of about 3 square feet, have natural drainage, and are exposed to natural weather conditions. In 1922 two crops were grown; first, a crop of barley for which the fertilizers were applied; and second, sorghum, which was grown as a residual crop without further fertilizer treatment. In 1923 a single crop of corn was grown. This was followed by a crop of oats which was left to die and form a mulch during the winter. In 1924 rape was grown as the main crop and this was followed by sorghum as a residual crop.

First Crop of 1925—Rape

After harvesting the sorghum in the fall of 1924 the cylinders were seeded to rye as a cover crop. This made fair growth so that by the middle of April, 1925, it was 10 to 14 inches high. This was spaded under as a green manure crop and fertilizers were applied in accordance with the plan. Dwarf Essex rape was seeded on April 24 and a good stand obtained. A fair crop was obtained though the yield was not equal to the 1924 crop. It was harvested July 1 and samples were dried, weighed, and prepared for analysis.

The dry weights and other data are shown in table 3. In studying the data included in the table, three points should be kept in mind: 1. the form of nitrogen used; 2. the amount of phosphoric acid; and 3. the amount of potash used.

Yields of Dry Matter

The yield of dry matter on all check cylinders was low, but was higher on those with the double portion of potash than on those with the single portion.

For the nitrogen treatments, nitrate of soda, with one exception (5-5-8 ratio), gave the highest yields of dry matter, and without exception ammonium sulfate gave the next highest. Dried blood gave the lowest yields for both the single and double portions of potash. This places the yields with the mixture containing the three sources of nitrogen, next to ammonium sulfate.

The average yields for the nitrogen treatments with the double portion of potash differ only slightly from the corresponding averages for the single portion.

TABLE 3

Rape (First Crop)—1925

NITROGEN TREATMENT	Dry Matter	Nitrogen		Nitrogen Recovered	Dry Matter	Nitrogen		Nitrogen Recovered	Dry Matter	Nitrogen		Nitrogen Recovered
	gm.	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*
	Ratio 5-5-4				Ratio 5-10-4				Ratio 5-15-4			
A. Check	15.0	1.952	0.293	....	17.7	1.981	0.351	....	17.0	1.523	0.259	....
B. Nitrate of soda	77.7	1.488	1.156	52.40	82.9	1.514	1.255	54.89	88.9	1.373	1.221	58.41
C. Ammonium sulfate	66.6	1.514	1.008	43.41	69.9	1.512	1.057	42.87	85.9	1.294	1.112	51.79
D. Dried blood	56.3	1.556	0.876	35.40	37.4	1.844	0.690	20.58	55.1	1.425	0.785	31.94
E. ⅓N from each	63.1	1.463	0.923	38.25	67.0	1.432	0.959	36.92	70.2	1.369	0.961	42.62
Average of 4 treated cyls.	65.9	1,505	0.991	42.37	64.3	1.576	0.990	38.82	75.0	1.365	1.020	46.19
	Ratio 5-5-8				Ratio 5-10-8				Ratio 5-15-8			
F. Check	21.6	1.716	0.371	....	29.2	1.394	0.407	....	28.4	1.439	0.409	....
G. Nitrate of soda	74.9	1.474	1.104	44.51	84.5	1.439	1.216	49.12	82.7	1.397	1.155	45.29
H. Ammonium sulfate	74.9	1.425	1.067	42.26	78.0	1.344	1.048	38.92	66.6	1.390	0.926	31.39
I. Dried blood	50.2	1.495	0.750	23.01	51.4	1.369	0.704	18.03	50.1	1.397	0.700	17.67
*J. ⅓N from each	73.2	1.336	0.978	36.85	61.1	1.428	0.873	28.29	69.1	1.245	0.860	27.38
Average of 4 treated cyls.	68.3	1.432	0.974	36.66	68.8	1.395	0.960	33.59	67.1	1.357	0.910	30.43

* Cyl. 2J omitted from average.

The nitrogenous fertilizers do not appear to have had much influence on the percentage of nitrogen in the dry matter, the averages being close to 1.4 to 1.5. The average percentage of nitrogen is slightly higher with the single than with the double portion of potash.

The percentages of nitrogen recovered in the crop follow quite closely the yields of dry matter. The recoveries with nitrate of soda, ammonium sulfate, and dried blood were in the order named. The recovery with the fertilizer containing the three forms of nitrogen was greater than with dried blood alone, but less than with nitrate of soda or sulfate of ammonia. The nitrogen recoveries with this crop may be summarized as follows:

	SINGLE PORTION P_2O_5	DOUBLE PORTION P_2O_5	TRIPLE PORTION P_2O_5
Average for the 4 nitrogen treatments—single portion of potash	42.4	38.8	46.2
Average for the 4 nitrogen treatments—double portion of potash	36.7	33.6	30.4

This summary shows that in only two cases do the average recoveries go over 40 per cent. The recoveries were less with the double than with the single portion of potash.

Residual Crop of 1925—Sorghum

Immediately following the harvesting of the rape, the cylinders were seeded to sorghum without additional fertilizer treatment, for the purpose of utilizing any residual nitrogen. The sorghum grew well and gave larger yields than the rape. The results for this crop are shown in table 4. In every case the yield with nitrate of soda was greater than with sulfate of ammonia. Three times out of six the dried blood gave larger residual yields than the nitrate of soda.

The average yields from the nitrogen treated cylinders with the single portion of potash were greater than the corresponding yields with the double portion of potash.

The percentage of nitrogen recovered was higher than usual for a residual crop. The highest average—18.46—was obtained with the 5-5-4 ratio. In all other cases the average recovery was less than 10 per cent. In most cases the dried blood gave higher residual recoveries than the other nitrogenous materials.

The Combined Crops—1925

The yields of dry matter and the percentage of nitrogen recovered for the two crops are combined in table 5.

The residual effect of the dried blood is clearly shown here. In the majority of cases, however, the yield of dry matter and the percentage of nitrogen recovered are higher with nitrate of soda than with either sulfate of ammonia or dried blood.

The average yields of dry matter show a distinct increase as phosphoric acid increased, but there does not appear to be any direct relationship between the percentage of nitrogen recovered and the amount of phosphoric acid used. In this connection, however, it may be pointed out that with the double portion of potash the lowest average nitrogen recovery is found where the double portion of phosphoric acid was used.

In all cases the average yields of dry matter and average percentage nitrogen recovered are lower with the double than with the single portion of potash.

Percentage Nitrogen Recovered—Combined Crops 1922-1925 Inclusive

Table 6 reports the percentage nitrogen recovered under the various treatments for the four years 1922 to 1925. A study of the figures shows that the highest recoveries were obtained with nitrate of soda, in the case of both the

TABLE 4

Sorghum (Second Crop)—1925

NITROGEN TREATMENT	Dry Matter	Nitrogen		Nitrogen Recovered	Dry Matter	Nitrogen		Nitrogen Recovered	Dry Matter	Nitrogen		Nitrogen Recovered
	gm.	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*
	Ratio 5-5-4				Ratio 5-10-4				Ratio 5-15-4			
A. Check	68.9	.730	.503	....	88.7	.653	.579	....	92.0	.640	.589	....
B. Nitrate of soda	108.8	.734	.799	17.97	146.9	.677	.995	25.26	120.2	.620	.745	9.47
C. Ammonium sulfate	72.9	.996	.726	13.54	84.6	.750	.635	3.40	113.3	.616	.698	6.62
D. Dried blood	104.7	.884	.926	25.68	115.8	.624	.723	8.74	148.0	.570	.844	15.48
E. ⅓N from each	97.4	.798	.777	16.64	94.8	.734	.696	7.10	97.9	.632	.619	1.82
Average of 4 treated cyls	96.0	.853	.807	18.46	110.5	.696	.762	11.13	119.9	.610	.727	8.35
	Ratio 5-5-8				Ratio 5-10-8				Ratio 5-15-8			
F. Check	71.8	.859	.617	....	72.6	.718	.521	....	92.5	.634	.586	....
G. Nitrate of soda	81.9	.766	.627	0.61	114.9	.680	.782	15.85	97.0	.685	.664	4.74
H. Ammonium sulfate	73.5	.948	.697	4.86	100.5	.715	.719	12.02	94.2	.669	.630	2.67
I. Dried blood	107.1	.709	.759	8.62	106.2	.702	.746	13.66	131.8	.583	.768	11.05
*J. ⅓N from each	90.9	.745	.677	3.64	80.3	.758	.609	5.34	96.2	.690	.664	4.74
Average of 4 treated cyls	88.4	.792	.690	4.43	100.5	.714	.714	11.72	104.8	.657	.682	5.80

* Cyl. 2J omitted from average.

TABLE 5

Yield of Dry Matter and Percentage of Nitrogen Recovered—Combined Crops, 1925

Nitrogen Treatment	Dry Matter	Nitrogen Recovered	Dry Matter	Nitrogen Recovered	Dry Matter	Nitrogen Recovered
	gm.	*per cent.*	*gm.*	*per cent.*	*gm.*	*per cent.*
	Ratio 5-5-4		Ratio 5-10-4		Ratio 5-15-4	
A. Check	83.9	....	106.4	....	109.0	....
B. Nitrate of soda	186.5	70.37	229.8	80.15	209.1	67.88
C. Ammonium sulfate	139.5	56.95	154.5	46.27	199.2	58.41
D. Dried blood	161.0	61.08	153.2	29.32	203.1	47.42
E. ⅓ N from each	160.5	54.89	161.8	44.02	168.1	44.44
Average of 4 treated cyls.	161.9	60.83	174.8	49.95	194.9	54.54
	Ratio 5-5-8		Ratio 5-10-8		Ratio 5-15-8	
F. Check	93.4	....	101.8	....	120.9	....
G. Nitrate of soda	156.8	45.12	199.4	64.97	179.7	50.03
H. Ammonium sulfate	148.4	47.12	178.5	50.94	160.8	34.06
I. Dried blood	157.3	31.63	157.6	31.69	181.9	28.72
J. ⅓ N from each	164.1	40.49	141.4	33.63	165.3	32.12
Average of 4 treated cyls.	156.7	41.09	169.3	45.31	171.9	36.23

single and double portion of potash. The second highest recoveries were with the fertilizer containing the three sources of nitrogen. With one exception only there is very little difference between the recoveries with ammonium sulfate and dried blood, the general average for these two materials with the single portion of potash being around 40 to 45 per cent. and with the double portion of potash, around 35 to 40 per cent. With the single portion of potash the nitrate of soda gave a general average close to 60 per cent., and with the double portion a general average of about 56 per cent.

In nearly all cases the recoveries are less with the single than with the double portion of potash. In the case of the nitrate of soda there is a tendency for the percentage of nitrogen recovered to increase with the increase in the amount of phosphoric acid used. This is especially noticeable in the case of the double potash application. With the other materials there is not a direct relationship between the percentage of nitrogen recovered and the amount of phosphoric acid used.

From the standpoint of the percentage of nitrogen recovered, and considering all the nitrogenous materials used, it would appear that a fertilizer having the ratio 5-5-4 gave the best results in this experiment. On the other hand, the highest yields were obtained in 1925 with a fertilizer having a ratio of 5-15-4.

Summary

This report marks the fourth year of the work on the availability of nitrogen with varying ratios of phosphoric acid and potash.

The plan provides for a constant amount of nitrogen from three different sources and also a combination of these three, in connection with the use of single, double, and triple portions of phosphoric acid and single and double portions of potash. With the exception of 1923, when corn only was grown, two crops have been grown each year. The fertilizer is applied for the first crop and the second crop is grown to utilize any nitrogen not taken by the first crop.

TABLE 6

Nitrogen Recoveries for the combined crops for the Years 1922-1925 Inclusive (7 crops)

Nitrogen Treatment		Single portion P_2O_5	Double portion P_2O_5	Triple portion P_2O_5
		per cent.	*per cent.*	*per cent.*
		Single Portion K_2O		
Nitrate of soda	1st year	61.2	73.4	82.3
	2nd year	40.6	38.4	43.9
	3rd year	56.8	57.3	49.5
	4th year	70.4	80.2	67.9
	Average	57.3	62.3	60.9
Ammonium sulfate	1st year	42.3	45.3	51.1
	2nd year	30.3	24.2	31.4
	3rd year	51.9	40.5	44.4
	4th year	57.0	46.3	58.4
	Average	45.4	39.1	46.3
Dried blood	1st year	37.5	67.2	55.6
	2nd year	21.4	19.0	25.6
	3rd year	55.7	47.8	43.9
	4th year	61.1	29.3	47.4
	Average	43.9	40.8	43.1
⅓ N from each	1st year	52.2	62.8	52.9
	2nd year	33.0	37.6	37.1
	3rd year	59.7	45.6	39.5
	4th year	54.9	44.0	44.4
	Average	50.0	47.5	43.5
		Double Portion K_2O		
Nitrate of soda	1st year	69.0	76.7	76.1
	2nd year	44.2	44.7	46.9
	3rd year	54.2	47.4	55.4
	4th year	45.1	65.0	50.0
	Average	53.1	58.5	57.1
Ammonium sulfate	1st year	37.4	48.1	46.0
	2nd year	28.7	31.8	31.7
	3rd year	45.3	43.6	39.0
	4th year	47.1	50.9	34.1
	Average	39.6	43.6	37.7
Dried blood	1st year	59.3	42.9	48.1
	2nd year	17.6	21.3	18.0
	3rd year	44.6	42.9	44.7
	4th year	31.6	31.7	28.7
	Average	38.3	34.7	34.9
⅓ N from each	1st year	40.4	50.5	55.6
	2nd year	22.7	32.7	29.2
	3rd year	44.2	41.4	37.9
	4th year	40.5	45.3	36.2
	Average	37.0	42.5	39.7

In 1925 rape was grown as the first crop and sorghum as the second.

For the first crop the yields of dry matter and the percentages of nitrogen recovered with nitrate of soda, ammonium sulfate, and dried blood were, with slight exception, in the order named.

With the double portion of potash the larger amounts of phosphoric acid caused a slight decrease in percentage of nitrogen recovered.

With the single portion of potash the highest nitrogen recovery was with the triple portion of phosphoric acid and the next highest with the single portion.

Generally the mixture containing the nitrogen from three sources gave higher recoveries than those obtained with dried blood alone, but lower than those with nitrate of soda and sulfate of ammonia.

In most cases the first crop recovered less than 50 per cent. of the applied nitrogen.

For the second crop there does not appear to be any direct relation between the nitrogen recoveries and the amounts of phosphoric acid and potash used.

The dried blood gave relatively higher recoveries with this crop than with the first crop.

For the combined crops the double portion of potash gave lower average yields and lower average recoveries than the single. Here also there does not appear to be any direct relation between the nitrogen recovered and the amount of phosphoric acid used.

For the combined crops the average recoveries vary from about 36 per cent. to 61 per cent.

The summary of the four years' work shows that the highest average recoveries were obtained with nitrate of soda.

In nearly all cases the recoveries were less where the double portion of potash was used than with the single portion. From the four-year averages of all the crops and all the nitrogen treatments it would appear that the double and triple portions of phosphoric acid did not give sufficient increase in nitrogen recovery to justify their use.

References

(1) Blair, A. W., and Prince, A. L. 1924. Influence of varying ratios of phosphoric acid and potash on crop yield and nitrogen recovery. *Soil Sci.* 17:327-331.

(2) Blair, A. W., and Prince, A. L. 1925. The availability of nitrogen in nitrate of soda, ammonium sulfate, and dried blood when the amounts of phosphoric acid and potash are varied. *Soil Sci.* 19:467-476.

(3) Lipman, J. G., and Blair, A. W. 1924. The influence of varying ratios of phosphoric acid and potash on the yield, and on the nitrogen and phosphoric acid content of the crop, with different nitrogenous materials. *N. J. Agr. Exp. Sta. Ann. Rpt.* 1923:213-222.

Continuous Wheat and Rye With and Without a Legume Green Manure Crop—Season 1925

This crop completes 17 years of continuous growing of wheat and rye on these plots. Two 1/20-acre plots are devoted to wheat and two to rye. One wheat plot and one rye plot are left in stubble or bare fallow between harvest and seeding time, while the other two plots are seeded to soybeans just after harvest, and the beans allowed to grow until about the middle of September, when they are plowed under as a green manure crop.

During the summer of 1924 the 2 plots without green manure crop were left in stubble, and much volunteer clover—red and alsike—came in. This tendency for clover to take possession of these plots during the summer has been noted previously. It is due, in part at least, to a generous use, annually, of lime and mineral fertilizers. It has not been possible to measure accurately the amount of nitrogen thus gained, but judging from the amount of nitrogen which clover has returned on other plots and from the effect on the wheat and rye which followed the clover, it seems safe to estimate a gain of 30 to 50 pounds per acre.

There was a good stand of well inoculated beans on plots 70 and 71, and when plowed under about the middle of September, the vines were at least 2 feet high with pods beginning to set. By weighing the yield of beans cut from 12 square feet, it was found that the yield (green weight) was at the rate of 6.8 tons per acre. On the dry basis this was approximately 1¼ tons per acre. When properly cared for, soybean hay contains about 3 per cent. of nitrogen. With a yield of 1¼ tons of dry matter per acre, this would mean 75 pounds of nitrogen returned to the soil through the beans that were plowed under. As noted above, the beans showed excellent inoculation and it is not unlikely that ¾ to ⅘ of this nitrogen was taken directly from the air.

A slight change was made in the plan of the experiment in 1925. This consisted in top dressing one-half of each plot with nitrate of soda at the rate of 160 pounds per acre. This was done because it seemed worthwhile to determine whether the legume-treated plots would respond to an additional supply of available nitrogen.

The yields and other data for 1925 are reported in table 7.

TABLE 7

Rye and Wheat Grown With and Without a Legume Green Manure Crop, Season 1925 (Calculated to Acre Basis)

Plot Number	SPECIAL TREATMENT	GRAIN			STRAW			Total Nitrogen
		Dry Matter	Nitrogen		Dry Matter	Nitrogen		
		lbs.	*per cent.*	*lbs.*	*lbs.*	*per cent.*	*lbs.*	*lbs.*
68	Rye alone	1140	1.911	21.79	3821	.248	9.48	31.27
68A*	Rye alone	1411	1.830	25.82	4950	.323	15.99	41.81
70	Rye followed by soybeans	1085	1.814	19.68	3976	.239	9.50	29.18
70A*	Rye followed by soybeans	1110	1.911	21.21	4662	.338	15.76	36.97
69	Wheat alone	1196	2.008	24.02	2849	.304	8.66	32.68
69A*	Wheat alone	1485	2.154	31.99	4315	.394	17.00	48.99
71	Wheat followed by soybeans	1113	2.050	22.82	2990	.408	12.20	35.02
71A*	Wheat followed by soybeans	1259	2.219	27.94	3863	.416	16.07	44.01

*The half plot on which top dressing was used.

This year the yields were better on the plots without green manure crop than on the plots with the green manure. This is no doubt due in large part to the volunteer clover which came in on the former. These plots gave an increase of nearly 5 bushels of rye and 5 bushels of wheat per acre as a result of the top dressing. In the case of the legume-treated plots the top dressing gave only slight increases.

With only one exception, the percentage of nitrogen in both grain and straw was higher where the top dressing was used than where it was not used.

The yields calculated on the acre basis may be summarized as follows:

	Top dressing	Without top dressing
	bu.	*bu.*
Rye—without legume	25.2	20.4
Rye—with legume	19.8	19.4
Wheat—without legume	24.8	19.9
Wheat—with legume	21.0	18.6

From this it would appear that the top dressing was much more effective on those plots where the volunteer clover came than on those plots where soybeans were seeded. It would also appear that lime and mineral fertilizers constitute a very important factor in the maintenance of soil fertility. Where these are used in generous amount, soil-enriching plants easily gain the ascendancy.

The Continuous Growing of Corn With a Legume and Non-Legume Green Manure Crop—Season 1925

The season of 1925 completed 19 years (18 years of corn) of work on the experiment on the continuous growing of corn with a legume and non-legume green manure crop. The special treatment is indicated in table 8. In addition to the special treatment, fertilizers were applied on the acre basis as follows:

Acid phospate	300 pounds	
Nitrate of soda	80 pounds	equivalent to 160 pounds nitrate of soda
Sulfate of ammonia	60 pounds	
Muriate of potash	50 pounds	

The cover crops—a mixture of clovers and vetch on plots 49-52, and rye on plots 53-56—were seeded during the late summer of 1924. Notes near the end of April, 1925, show that there was a fair stand of vetch and clovers on 49-52 and of rye on 53-56.

The land was plowed and prepared about the last of April, and the manure and fertilizer were applied broadcast and corn was planted May 7.

A good stand was secured and the corn was given the usual cultivation during the season. It was harvested September 18, dried and weighed, and samples were prepared for analysis. The dry weights and other data are shown in table 8. Without exception the plots in the legume section gave higher yields of grain than those in the non-legume section, the average for the former being 3,628 pounds or 64.8 bushels per acre and for the latter 2,988 pounds or 54.4 bushels per acre. Thus there was an increase in favor of the legume section of over 11 bushels per acre.

For both the legume and non-legume sections the manure treatment gave some increase over the non-manured plot. In each case the largest yield was with the 4,000 pounds of manure. In each case also the increase with 1,000 pounds of manure was slightly greater than the 2,000 pounds. The legume section showed a higher percentage of nitrogen in grain, stalks, and cobs than the non-legume section. The average total nitrogen returned in the crop from the legume section was 67.7 pounds per acre and the average from the non-legume section 46.8 pounds.

The results show a distinct advantage in using a legume cover crop rather than a non-legume cover crop at the last cultivation of corn. They also indicate that there is some gain in using very small applications of manure in connection with the growing of green manure crops.

The Influence of Fertilizers on the Composition of the Soil[1]

Much has been written about the composition of the soil and the methods of maintaining soil fertility. Does a chemical analysis aid in determining the value of a soil and does it show whether that soil is increasing or decreasing in fertility?

These are questions which are very often asked. They are questions which are not easily answered directly, for the evident reason that the volume of the cultivated soil over an acre is very great in comparison with the volume of fertilizer that is applied to that acre. In other words, the volume of fertilizer that is applied in a given year is rarely sufficient to change the composition of the soil to such an extent that it can be detected by the ordinary methods of chemical analysis. On the other hand, the treatment of a soil with fertilizers for a period of years or the withholding of fertilizers and soil amendments may bring about changes that can be detected by analysis.

---

[1] Analyses by Mr. A. L. Prince.

TABLE 8

Continuous Corn With Legume and Non-Legume Crop—Season 1925 (Calculated to Acre Basis)

PLOT NUMBER	SPECIAL TREATMENT	GRAIN			STALKS			COBS			Total Nitrogen	Increase Over Check
		Dry Matter	Nitrogen		Dry Matter	Nitrogen		Dry Matter	Nitrogen			
		lbs.	*per cent.*	*lbs.*	*lbs.*	*per cent.*	*lbs.*	*lbs.*	*per cent.*	*lbs.*	*lbs.*	*lbs.*
	LEGUME SECTION											
49	No manure	3180	1.354	43.06	1612	.693	11.17	640	.322	2.06	56.29	....
50	50 lbs. manure	3750	1.332	49.95	2168	.854	18.51	670	.284	1.90	70.36	14.07
51	100 lbs. manure	3730	1.380	51.47	2476	.751	18.59	690	.258	1.78	71.84	15.55
52	200 lbs. manure	3850	1.428	54.98	2412	.622	15.00	730	.290	2.12	72.10	15.81
	Average	3628	1.374	49.87	2167	.730	15.82	683	.289	1.97	67.66	15.14
	NON-LEGUME SECTION											
53	No manure	2680	1.057	28.33	1940	.548	10.63	470	.284	1.33	40.29	....
54	50 lbs. Manure	3060	1.193	36.51	1976	.548	10.83	550	.290	1.60	48.94	8.65
55	100 lbs. Manure	3010	1.145	34.46	2172	.526	11.42	560	.300	1.68	47.56	7.27
56	200 lbs. Manure	3200	1.177	37.66	1812	.596	10.80	600	.348	2.09	50.55	10.26
	Average	2988	1.143	34.24	1975	.555	10.92	600	.306	1.67	46.84	8.73

Much depends upon the kind of soil, the cropping system, and the amount of fertilizer used. It is believed that some work that has recently been done at this Station may throw light on this question.

In 1919 the department of soil fertility investigations of the Bureau of Plant Industry at Washington, drew up a plan for a cooperative fertilizer experiment with potatoes, to be carried on at this Station. The plan adopted was the so-called "triangle arrangement" which provides for plots without fertilizer and also plots with varying ratios of nitrogen, phosphoric acid, and potash.

The experiment was located on Penn loam soil which was slightly above the average in quality, and the rotation adopted was one of 3 years—corn, potatoes, alfalfa. The fertilizer was applied for the potatoes at the rate of 1,500 pounds per acre and for the corn at the rate of 500 pounds per acre. No fertilizer was applied for the alfalfa. This means that each year the corn and potato sections were fertilized and the alfalfa section was left without fertilizer. The experiment includes 5 check plots (no fertilizer), 21 plots in the triangle, and 2 extra plots. The nitrogen was applied in the form of nitrate of soda and sulfate of ammonia, one-half the nitrogen from each. The first crops were grown in 1919.

In 1924 after the potatoes had been harvested, samples of soil were collected from the various plots for analysis. These samples were taken to the depth of 6⅔ inches. After being dried they were passed through a 2-mm. sieve, prepared for analysis, and the following determinations made: total nitrogen, phosphoric acid, and potash, lime requirement by the Veitch method, and pH values.

The results are given in table 9, which also shows the fertilizer ratios used for the different plots.

An examination of the column giving the percentages of nitrogen in the soil shows that the lowest was 0.102 per cent. and the highest, 0.144 per cent. nitrogen. Of the entire lot of samples there are 16 that show 0.121 per cent. or more. Four of these fall in the class that received no nitrogenous fertilizer whatever (check) and 7 others fall in the class of those that received no nitrogen, or only 3 per cent. The remaining 5 plots of the 16 received a fertilizer containing more than 3 per cent. nitrogen. All the other plots showed less than 0.121 per cent. nitrogen, whether they were check plots or received a fertilizer high in nitrogen. This would seem to indicate quite clearly that in a period of 6 years the nitrogen content of this soil was not at all influenced by the fertilizers that were used. This does not mean that it would not be influenced should the work be continued for a longer period. Indeed, previous work (1) has shown that soils do become depleted in nitrogen when nitrogenous fertilizers are withheld for a long period. On the other hand, it has been shown that it is exceedingly difficult to increase the nitrogen content of soils to an appreciable extent.

In the case of the phosphoric acid treatment, the differences are more pronounced. The three plots that receive the highest percentage of phosphoric acid show the highest amount of phosphoric acid in the soil—an average of slightly over 0.3 per cent. Two plots which receive a fertilizer with 9 per cent. phosphoric acid show 0.252 and 0.244 per cent. phosphoric acid, whereas the check plots and those that receive a fertilizer with low percentage of phosphoric acid show less than this amount. It would appear that the phosphoric acid content of the soil has been slightly affected by the applications of fertilizer containing phosphoric acid. Inasmuch as phosphoric acid is but slightly lost in the drainage waters, this result would be expected, especially in the case of potatoes where but little phosphoric acid is removed by the crop.

There is little evidence that the potash treatments have had any influence on the potash content of the soil. Some of the plots that receive no potash or only small percentages, show as much total potash in the soil as those that receive heavy applications of potash salts. As previously explained, this must be attributed to the fact that the total amount of potash in the plowed acre is very great, even in comparison with the largest amount applied in the form of commercial fertilizers.

TABLE 9

Partial Analysis of Soils from Triangle Fertilizer Experiment, Bureau of Plant Industry, U. S. D. A., and N. J. Agricultural Experiment Station Cooperating. Samples Taken 1924.

Plot No.	Fertilizer Ratios	Fertilizing Constituents in Soil			Lime Requirement	pH
		N	P_2O_5	K_2O		
	N P_2O_5 K_2O	*per cent.*	*per cent.*	*per cent.*	*lbs.*	
Check 1	0 — 0 — 0	0.134	0.229	1.620	700	6.8
2	0 — 0 — 0	0.129	0.213	1.740	200	6.8
3	0 — 0 — 0	0.121	0.215	1.775	200	7.0
4	0 — 0 — 0	0.107	0.176	1.887	200	7.0
5	0 — 0 — 0	0.128	0.203	1.693	alk.	7.0
Plot 1	0 — 15 — 0	0.141	0.294	1.852	1400	6.6
2	0 — 12 — 3	0.135	0.320	2.124	1800	6.4
3	3 — 12 — 0	0.129	0.299	2.136	1800	6.4
4	0 — 9 — 6	0.119	0.213	1.507	1000	6.8
5	3 — 9 — 3	0.142	0.252	1.798	1200	6.6
6	6 — 9 — 0	0.144	0.244	1.879	800	6.6
7	0 — 6 — 9	0.123	0.229	1.430	200	6.8
8	3 — 6 — 6	0.102	0.231	1.553	800	6.8
9	6 — 6 — 3	0.122	0.218	1.565	1200	6.5
10	9 — 6 — 0	0.120	0.205	1.662	400	6.8
11	0 — 3 — 12	0.110	0.212	1.511	800	6.8
12	3 — 3 — 9	0.111	0.220	1.557	1000	6.8
13	6 — 3 — 6	0.114	0.190	1.507	600	6.8
14	9 — 3 — 3	0.115	0.231	1.434	800	6.8
15	12 — 3 — 0	0.122	0.208	1.414	1000	6.5
16	0 — 0 — 15	0.115	0.192	1.457	1000	6.6
17	3 — 0 — 12	0.116	0.182	1.488	300	7.0
18	6 — 0 — 9	0.114	0.198	1.414	400	6.6
19	9 — 0 — 6	0.114	0.205	1.402	1200	6.6
20	12 — 0 — 3	0.114	0.187	1.496	alk.	7.2
21	15 — 0 — 0	0.126	0.205	1.488	400	6.6
22	3 — 9 — 3	0.125	0.237	1.426	200	7.0
23	3 — 9 — 3	0.125	0.238	1.472	alk.	7.0

There is likewise little evidence of a relationship between the lime requirement of the soil and the fertilizers that were used. It may be pointed out that the plots showing the highest lime requirements and the lowest pH values are the ones which received the largest amount of phosphoric acid. This condition, however, should probably be attributed to accidental circumstances rather than to a direct relationship, inasmuch as there is much evidence which would lead one to conclude that acid phosphate does not increase the acidity of soils.

The work makes it quite clear that one need not expect rapid changes in the composition of soils due to the use of commercial fertilizers. It also emphasizes the importance of using great care in collecting samples, if chemical analyses are to be made, and undoubtedly there are circumstances under which such analyses are fully justified.

References

(1) Lipman, J. G., and Blair, A. W. 1921. Nitrogen losses under intensive cropping. *Soil Sci.* 12:1-16.

THE TREATMENT OF ALKALI SOILS WITH $AlPO_4$

J. S. JOFFE AND H. C. McLEAN

Investigations conducted in the laboratories of this Station and reported in a series of papers (1, 2, 3, 4) have shown that any rational system of alkali soil treatment must take into consideration the following principles: 1. coagulation of colloids; 2. washing out excess of soluble salts; 3. replacement of the so-called undesirable zeolitic cations, such as Na; 4. creating a reaction favorable for plant growth; and 5. compensating the loss of plant food caused by the methods of amelioration involving principle 2.

With this in mind native minerals of aluminum phosphate were tried out. It was thought that the free alkali of the alkali soil medium would react with the insoluble phosphates to form $Al(ONa)_3$, and thus set free some Al ions which would serve as a coagulant; at the same time some of the PO_4 ions present in the soil solution would be either available, or become precipitated in combination with the Ca ions. The sum total of the possible influence of $AlPO_4$ would be to facilitate the leaching capacity of the soil, because of coagulation (principle 2), and to retain the Ca ions which would combine with the phosphate anion thus augmenting the phosphorus content (principle 5).

Parallel with the aluminum phosphate treatment another series was treated with sulfur. The acid produced from the sulfur would not suffice to increase the H-ion concentration to the solubility point of the phosphates, since the latter go into solution only at a H-ion concentration equivalent to pH 4.2-4.4; still there might be local action around the particles of the $AlPO_4$ in direct contact with the sulfur.

With the foregoing as a theoretical basis, the experiment as outlined in table 10 was started.

The soil used was obtained from the California Experiment Station, Riverside, California, but originally came from Fresno. In texture it is a sandy loam, strongly alkaline with a pronounced soda odor, having a pH varying

TABLE 10

Treatment of alkali soils

Laboratory Number	TUMBLERS*		POTS†	
	Additions made		Additions made	
	Sulfur	$AlPO_4$	Sulfur	$AlPO_4$‡
	gm.	*gm.*	*gm.*	*gm.*
1		1.00	2.5	5.0
2		1.00	2.5	5.0
3		1.00	2.5	5.0
4		1.00	2.5	5.0
5		1.00	2.5	5.0
6	0.5		2.5	5.0
7	0.5		2.5	5.0
8	0.5		2.5	5.0
9	0.5		2.5	5.0
10	0.5		2.5	5.0
11	0.5	1.00		5.0
12	0.5	1.00		5.0
13	0.5	1.00		5.0
14	0.5	1.00		5.0
15	0.5	1.00		5.0
16	0.5	1.00	2.5	
17	0.5	1.00	2.5	
18	0.5	1.00	2.5	
19	0.5	1.00	2.5	
20	0.5	1.00	2.5	
21			0.0	0.0
22			0.0	0.0
23			0.0	0.0

* 200 gm. of soil per tumbler.

† 1000 gm. of soil per pot.

‡ Native aluminum phosphate from Pennsylvania, finely ground, 28.29 per cent. P_2O_5.

from 9.6 to 8.8, depending chiefly on the increase or decrease of carbonates and bicarbonates. The tumblers and pots were kept at room temperature. The pots had holes in the bottom for leaching. Samplings for extractions were made from the soil in the tumblers. The pots were leached at various intervals as indicated in tables 10 and 11.

The extractions were made as follows: 50 gm. of soil were taken from the tumbler and mixed with 50 cc. of distilled water, left over night with occasional shaking, centrifuged, and decanted.

The pots were treated with 300 cc. of distilled water, the leachings made up to 200 cc., and aliquotes used for analysis.

The analytical methods used were the same as reported in the papers already published (1, 2).

Table 11 gives the analyses of the leachings.

A glance at the data obtained after 30 days' incubation shows a decrease of the carbonates in pot 12 ($AlPO_4$ treated). This indicates that the alkali substances did react with the insoluble phosphates. The phosphorus content on the other hand increased, showing that some of the phosphate anions remained in solution but did not combine with the calcium ions as anticipated.

It has been pointed out (3, p. 142-145) that this particular alkali soil contains large quantities of replaceable Ca; however, the Al ions have not replaced any of them.

Apparently there is no such complex with replaceable Al or Fe. Whenever Al and Fe appear in leachings or extracts, their origin is to be sought in the decomposition of the skeleton framework of the aluminum silicate molecule or other mineral constituents of the soil.

This problem is of extreme interest and commands more attention and further careful study.

In scrutinizing the data on the effects of the Al ions, one may turn his attention to the leaching capacity of the soils. The pots with the aluminum phosphate treatment have developed a higher leaching capacity as expressed by the speed of percolation. After 80 days and after subsequent intervals[1] the $AlPO_4$ treated soil leached faster than the controls. As pointed out this is due to the coagulation effect of the trivalent Al ion which is set free in the reaction between the alkali and the $AlPO_4$.

With the utilization of the alkali, H-ion concentration of the surrounding medium is increased, as shown by the pH values recorded. The $AlPO_4$ had no outstanding effect on any other constituents of the alkali soils save the carbonates, bicarbonates, phosphorus, and on the reaction and leaching capacity.

There is no need of going over the results of the sulfur treatments as they appear in table 11, for extensive discussions of the subject have already been published (1, 2, 3, 4).

A short discussion on the effects of the sulfur-aluminum phosphate treatments may not be out of place.

It will be noticed that the individual effects of the $AlPO_4$ are obliterated when the compound is mixed with the sulfur. Preliminary qualitative studies showed that immediately after mixing $AlPO_4$ and sulfur with the soil, the alkali did react with the insoluble phosphates. It would appear that when the sulfur began to oxidize, the aluminum phosphate and alkali of the soil no longer reacted to form sodium aluminate. What probably happened was a precipitation of the aluminum as the hydroxide, while the phosphate combined with the large amounts of Ca set free by the H ions from the oxidized sulfur as shown in the Ca column. The 30-day incubation data corroborate the qualitative reactions just described, the bicarbonate content being lower in aluminum phosphate + sulfur treatment. With the advance of the sulfur oxidation the quantities of bicarbonates are alike in the sulfur and aluminum phosphate-sulfur treatments.

The reactions exhibited by the extracts corroborate the data on the leachings, as illustrated in table 12, but the data on the extracts present a feature not shown by the data on the leachings.

---

[1] Leachings were made after 165 and 225 days but to save space these are omitted.

TABLE 11

Analyses of leachings after various incubation periods

Laboratory Number of Treatment	C as CO_3	C as HCO_3	Cl	Ca	Mg	Fe	SiO_2	Na	K	P	S	Leachings	Reaction
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*cc.*	*pH*
AFTER 30 DAYS													
22	16.27	93.62	2855	4.42	5.94	6.71	1.73	2239.5	77.21	8.57	492.9	188*	8.8
12	12.45	63.04	2865	4.81	4.46	6.71	2.53	2145.8	72.06	15.14	464.2	180*	8.6
17	0	21.05	2440	105.86	34.77	4.47	2.26	2070.7	86.22	2.10	499.2	160†	8.2
2	0	11.21	2475	109.07	35.73	3.35	1.73	1762.5	45.04	2.92	602.3	165†	8.0
AFTER 80 DAYS													
23	20.68	67.36	....	16.84	4.11	....	1.73	2898.9	104.23	2.64	585.93	138‡	9.0
13	10.19	60.97	3080	13.63	4.19	....	2.20	2994.1	120.96	9.68	589.35	150	8.6
18	0	11.40	2575	109.87	70.49	....	2.40	2814.3	140.26	29.08	1042.37	153	8.0
3	0	11.60	3000	112.68	89.11	....	1.73	3170.8	153.13	3.72	1028.28	158	8.0
AFTER 135 DAYS													
14	7.64	59.69	2850	23.07	13.45	5.60	1.4	....	....	25.72	566.5	173	....
19	0	6.09	2400	104.12	95.66	5.60	1.1	....	....	2.92	1098.7	179	....
4	0	6.09	2850	96.09	130.60	44.83	1.3	....	....	3.64	1060.4	160	....

* No water remained on surface after 96 hours.
† No water remained on surface after 24 hours.
‡ No water remained on surface after 144 hours.

TABLE 12.

Analyses of alkali soil extracts from tumblers after various incubation periods

Laboratory Number of Treatment	C as CO_3	C as HCO_3	Cl	Ca	Mg	Na	K	P	SiO_2	S	Reaction
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*ph*
AFTER 30 DAYS											
1	5.92	314.7	4332	170.4	170.3	4085	353.8	86.6	800	820.4	8.4
6	0	123.5	4125	461.2	161.6	5095	434.3	23.9	283	1613.5	7.7
11	0	121.6	4375	421.1	144.1	4824	386.0	37.6	267	1504.1	7.4
AFTER 70 DAYS*											
1	73.5	250.4	4105	150.4	170.4	4409	140.0	125.4	492	814.9	8.6
6	0	68.7	4020	641.6	183.5	4600	160.0	25.1	25	1963.5	7.4
11	0	68.7	4125	761.9	174.7	4723	180.0	25.1	18	2083.9	7.3
AFTER 110 DAYS											
2	Trace	340.0	4110	140.3	....	4370	184.0	125.0	....	820.4	8.2
7	0	77.7	4090	1032.5	161.6	4743	284.0	18.0	....	2351.9	8.0
12	0	60.8	4090	1142.8	185.6	4231	400.0	33.0	....	3164.8	7.6
AFTER 165 DAYS											
3	27.4	415.9	4100	275.8	262.0	....	472.9	164.0	....	....	8.8
8	0	72.8	4100	1539.6	441.1	....	778.5	26.2	....	....	6.8
13	0	37.2	4100	1624.8	436.8	....	804.2	45.6	....	....	6.6

* N was determined on the extracts and found as follows: No. —1223; No. 6—943.6; No. 11—976 *p.p.m.*

As a result of the immediate reduction of the alkalinity due to the $AlPO_4$, the speed of sulfur oxidation was greater in the $AlPO_4$ + sulfur treated soils than in the soils with sulfur alone, as may be judged from the sulfur column. Apparently the coagulation of the colloids, due to the Al ions, facilitated aeration, which is a very important factor in the process of sulfur oxidation.

Frequent attempts to demonstrate a higher Al concentration in the $AlPO_4$ + sulfur treated soils failed. There were indications of an increased concentration of Al ions in the soils treated with $AlPO_4$ only.

In summing up, the following may be said:

Favorable influences of the $AlPO_4$ have been established and they seem to be of a permanent nature. It must be recognized, however, that these influences are not of enough importance to figure in any scheme of alkali soil amelioration. Where such minerals as $AlPO_4$ are cheaply and easily accessible, they might be used in combination with sulfur; the importance of the latter has been extensively discussed in the papers referred to above. The $AlPO_4$ may become a potential source of phosphorus.

The authors feel that more work in this direction would be profitable; it may yield more light on this important subject of alkali soil amelioration.

References

(1) Joffe, J. S., and McLean, H. C. 1924. Alkali soil investigations: I. A consideration of some colloidal phenomena. *Soil Sci.* 17:397-409.
(2) Joffe, J. S., and McLean, H. C. 1924. Alkali soil investigations: II. Origin of alkali soils; physical effects of treatments. *Soil Sci.* 18:13-30.
(3) Joffe, J. S., and McLean, H. C. 1924. Alkali soil investigations: III. Chemical effects of treatments. *Soil Sci.* 18:133-149.
(4) Joffe, J. S., and McLean, H. C. 1924. Alkali soil investigations: IV. Chemical and biological effects of treatments. *Soil Sci.* 18:237-223.

MAKING ARTIFICIAL MANURE FROM SALT MARSH HAY BY THE "ADCO" PROCESS

H. C. McLEAN

During the past few years considerable interest has been aroused with reference to processes for making artificial manure from straw, leaves, and vegetable wastes. Such a process was developed at the Rothamsted Experimental Station, Harpenden, England, and manure so made has been used on various crops at that Station since 1919. In field tests the crop yields obtained with artificial manure were practically the same as those with farmyard manure. A syndicate called the Agricultural Development Company (ADCO) has been formed to manufacture and sell "ADCO" reagent, which is the essential material required for making artificial manure. This reagent is now being sold in the United States. The cost of the material, according to a quotation given the writer in the spring of 1925, was approximately 4 cents a pound in ton lots, f.o.b. New York City.

Mr. J. C. Shoemaker of Riverview Farms, Bridgeton, N. J., having at his disposal a large quantity of salt hay which he thought could be turned into artificial manure cheaply enough to be used on his truck crops, became interested in the process. The Experiment Station offered to cooperate with him and experiments were started at his farm during the summer of 1925.

An analysis of the reagent used was made by the writer with the following result:

	Per cent.
Total nitrogen	8.23
Water-soluble nitrogen	7.95
Ammonia nitrogen	2.24
Total P_2O_5	9.46
Water-soluble P_2O_5	Trace
Total K_2O (all water-soluble)	2.50

The material also contains a considerable amount of lime which is used to maintain the compost at the proper reaction for active fermentation.

Contrary to the general belief, the reagent contains no special bacteria for inoculating the compost. It only supplies food and creates favorable conditions for the active development of organisms which thrive under an alkaline environment. Such organisms are always present on straw or other materials used in making up the compost.

Compost 1

Three tons of old discolored salt marsh hay was used in making up this compost. The pile was made with a base 12 feet by 30 feet. The first layer of about 1 foot of hay was sprayed with water until it appeared thoroughly wet and ADCO reagent was scattered uniformly over the moistened hay. The reagent was applied at the rate of 150 pounds per ton of dry hay. Another layer was then spread over the first layer, moistened as before and the reagent applied. This operation was repeated until the entire 3 tons of hay was in position. This gave a compost heap 6 feet in height. The heap was watered every few days to prevent drying. It was estimated that from 700 to 800 gallons of water was required to moisten each ton of hay throughout the compost period, which would be about 2,400 gallons for the entire lot. For this reason composts of this nature must be located near a good water supply. As the compost was made on the ground, care had to be used when watering to prevent the leaching out of the nitrogen and potash of the reagent. An ideal place for making the manure would be in a concrete pit or vat, so that any material leaching out could be pumped back onto the heap.

It was found impossible to wet this compost uniformly, hence only spots in the heap absorbed enough water to cause rotting and give the final product desired.

M. J. Scott[1] obtained results similar to the above. He made composts using wheat, oats and barley straw, and grass. With the exception of grass he found that all the materials decomposed uniformly.

Compost 2

This compost was made with green hay containing 1,200 pounds of air-dry material. ADCO reagent was added in the same proportion as in the compost 1.

The material in this case could be maintained at a uniform moisture content. After a few days, fermentation was very active and the temperature inside the compost was so high that one could not hold his hand there with comfort. After 3 months the compost settled to about one-sixth of its original size and looked like an ordinary manure heap. The final product had a dark brown color and was found to break easily when twisted in the hands.

At the time samples were taken for analysis, the entire compost weighed 2,850 pounds. Analysis showed the air-dry product to have the following composition:

	Per cent.
Nitrogen	1.89
P_2O_5	0.884
K_2O	0.75

No comparative field experiments were made with the artificial manure and barnyard manure, because Mr. Shoemaker decided that the product would be too expansive for his use, considering cost of material and labor.

Compost 3

To a pile of the original hay like that used in compost 1 there was added a small amount of manure and this was moistened and allowed to stand for the same length of time as composts 1 and 2. At the end of the compost period the material had a texture entirely different from the other composts. The material in the spots where it had become saturated with water felt slimy, because of the development of an entirely different microbial flora. In composts 1 and 2 the reagent had brought about conditions favorable for the development of the proper organisms.

---

[1] The making of artificial farmyard manure; trials at Lincoln. *New Zealand Journal of Agriculture*, 30 (1925) :91-93.

It is no doubt true that good manure may be made from certain waste products by this process, but the expense of the process may be a limiting factor in this country.

SOIL MICROBIOLOGY

S. A. Waksman

The results obtained during the year 1925-26 in Soil Microbiology can be summarized as follows:

A detailed study was made of the origin of humus in the soil, the micro-organisms concerned in the transformation of the natural organic substances, and the chemical processes involved. Soil humus or the organic matter of the soil, which is more or less resistant to decomposition and which persists for a considerable period of time in the soil, is due on the one hand to the accumulation of certain constituents of the natural organic materials, such as the lignins which are more resistant to decomposition than the other plant constituents, and to the synthesis of new substances by the micro-organisms; some of the constituents of these synthesized materials are very resistant to decomposition and form a part of the soil humus. When natural organic matter is added to the soil the soluble carbohydrates and proteins are first to be decomposed, soon followed by the decomposition of pentosans, celluloses, and various hemi-celluloses and proteins. The lignins, cutins, and fats are decomposed to a lesser extent. Within a period of 1 to 3 months, under favorable soil conditions, 80 per cent. of the organic matter may be decomposed—50 per cent. of the carbon is given off in the form of various gaseous products, largely carbon dioxide, and 30 per cent. remains in the soil in the form of certain intermediary products and synthesized cell substance. The residual materials and this cell substance are the chief direct sources of humus in the soil. These processes result in a narrowing of the carbon-nitrogen ratio of the organic matter from 80 or 40 to 1 to a ratio of 10 to 1 in the soil humus. The processes are somewhat different under anaerobic conditions. A detailed study of the origin of peat is being undertaken at present. There are very few organisms capable of decomposing the soil humus; among these organisms the actinomyces seem to play an outstanding role. Conditions which favor the development of these actinomyces, namely lime (tending to make the soil reaction neutral) and drainage (or proper aeration), will, therefore, favor the decomposition of the soil humus.

Report of the Department of Soils and Crops

LINWOOD L. LEE[1]

COMPLETION OF SOIL SURVEY

In cooperation with the United States Department of Agriculture, the Department of Soils and Crops brought to completion the soil survey of the Camden area by the survey of 310 square miles. The survey of the entire state has now been completed. It is noteworthy that New Jersey is the only state having a complete survey embodying all the most recent correlations of the United States Bureau of Soils.

COMPLETION OF THE BERGEN AREA REPORT

During the year the manuscript of the report of the soil survey of the Bergen area was completed and forwarded to the Bureau of Soils of the United States Department of Agriculture for publication.

A COMPILATION OF THE SOIL SURVEY DATA

Composite information concerning the collective soil information of the state has been brought together through an analysis of the various soil survey reports. By this work the soils of the state have been grouped: first, in order of the relative extent; second, according to series; and third, according to texture.. These data appear in the appendix of this report, a summary of which points out that there are 164 different and distinct soil types found within the state, including 50 soil series and 10 miscellaneous types.

SOIL CLASSIFICATION AND UTILIZATION IN NEW JERSEY

An account of soil classification and utilization in New Jersey, which is herewith briefly summarized, appears in the appendix of this report.

Summary

1. The soil survey of the state has been completed. It represents an accurate soil map of the entire state and a reliable economic classification and inventory of our soil resources as concerns relative productivity.
2. The method of classification is an economic one. Soils having similar characteristics are grouped into identical series. Soil types represent mechanical variations within the soil series.
3. There are five major soil zones in New Jersey.

---

[1] Specialist in Land Utilization.

4. The principal soils of each zone are described and their extent and present utilization discussed.
5. The extent of the agricultural soils of north and south Jersey are listed. There are two classes; namely, well drained and imperfectly drained.
6. Crop adaptation to specific soil types is discussed. Certain crops are especially adapted to specific soil types.
7. Drainage is discussed briefly. There are two phases; namely, local and general.
8. The extent of the imperfectly drained soils of the state is listed.
9. The extent of the non-agricultural soils in north and south Jersey is listed. These soils should remain in forest or permanent pasture.
10. A land development policy for the state is discussed and recommended for adoption.
11. Soil types as a basis for station experimental and demonstration projects are discussed. It is suggested that all station work be placed on a soil foundation in order that more accurate results applicable to the greatest number of our rural population be obtained.
12. The cooperation and assistance of the soils departments of the station are at all times available to all departments and divisions.

LAND UTILIZATION

Considerable material has been collected for a comprehensive report concerning land utilization of the state. This material points out in addition to the material included in the report on soil classification and utilization: first, that there are certain lands within the state better adapted to forestry than to agriculture; second, certain lands which in the near future will be utilized for building sites; and third, certain economic values can be placed on, and producing power determined for, specific soil types within the state. This material should be completely worked up in detail as quickly as possible and a report on land utilization published.

A FERTILIZER EXPERIMENT IN BURLINGTON COUNTY

A fertilizer experiment was set out on the farm of John Heal located at Beverly, Burlington County. In this experiment 59 plots of 345 square feet each were utilized in testing the results on sweet corn of various fertilizers and treatments. The following factors are being studied: 1. Sources of nitrogen in a complete fertilizer. 2. Method of application. 3. Amount of application. 4. Rates of potash. 5. The application of concentrated mixtures. 6. A comparison of side-dressing treatment; nitrate of soda, sulfate of ammonia and no side dressings. This experiment is being carried on in cooperation with the American Fertilizer Association through a fellowship established in the College and also in cooperation with the county agent of Burlington County. The complete data of this project to date are given in Appendix 5.

A FERTILIZER EXPERIMENT IN MONMOUTH COUNTY

A fertilizer experiment in Monmouth County has been set out on the farm of Mr. J. J. Warnock, near Hazlett. In this experiment 61 plots, 648 square feet each, are being utilized in testing various fertilizer treatments on sweet corn and tomatoes. The factors being tested are: 1. Method of application. 2. Amount of application. 3. The application of concentrated mixtures. 4. The time factor in applying potash. 5. Side dressings of nitrate compared with no side dressings. Complete data concerning this experiment are recorded in Appendix 6. This experiment has also been carried on in cooperation with the fellowship established in the College by the American Fertilizer Association and in cooperation with the county agent.

APPENDIX 1

Acreage of Soil Types of New Jersey in Order of Relative Extent

		Acres
1.	Sassafras Sand	480,320
2.	Lakewood Sand	247,424
3.	Sassafras Gr. Sandy Loam	207,178
4.	Tidal Marsh	185,152*
5.	Sassafras Loam	184,290
6.	Swamp	175.680
7.	Sassafras Sandy Loam	168,918
8.	Rough Stony Land	157,120
9.	Penn Silt Land	123,648
10.	Chester Gravelly Loam	107,072
11.	Sassafras Loamy Sand	100,864
12.	Meadow	97,306*
13.	Sassafras Fine Sandy Loam	90,536
14.	Penn Shale Loam	79,232
15.	St. Johns Sand	78,720
16.	Dutchess Shale Loam	62,592
17.	Chester Stony Loam	60,864
18.	Gloucester Stony Loam	55,104*
19.	Collington Fine Sandy Loam	54,464
20.	Portsmouth Sandy Loam	52,672
21.	Washington Loam	45,248
23.	Bormudian Silt Loam	43,556
24.	Hyde Loamy Sand	41,216
25.	Lansdale Silt Loam	40,896
26.	Collington Loam	32,128
27.	Lakewood Sand (Shallow Phase)	31,808
28.	Muck	31,744
29.	Montalto Stony Loam	31,040
30.	Lakewood Sandy Loam (Deep Phase)	30,912
31.	Sassafras Coarse Sand	30,440
32.	Rock Outcrop	28,160
33.	Croton Silt Loam	27,008*
34.	Dutchess Loam (Shaly Phase)	26,688

---

*Additional acreage not as yet computed.

		Acres
35.	Hoosic Gravelly Loam	26,240
36.	Sassafras Fine Sand	25,920
37.	Sassafras Sand (Mixed Phase)	25,856
38.	Freneau Loam	25,856
39.	Dover Loam	25,664
40.	Coastal Beach	24,448
41.	Collington Sandy Loam (Deep Phase)	24,064
42.	Shrewsbury Sandy Loam	23,616
43.	Sassafras Sandy Loam (Deep Phase)	23,488
44.	Culvers Stony Loam	23,360
45.	Gloucester Gravelly Loam	23,296*
46.	Collington Sand	23,296
47.	Hagerstown Silt Loam	23,168
48.	Lansdale Gravelly Loam	23,040
49.	Penn Gravelly Loam	22,464
50.	Whippany Silty Clay Loam	22,144
51.	Dover Stony Loam	21,632
53.	Montalto Silt Loam	18,944
52.	Papakating Silt Loam	19,264*
54.	Lakawanna Stony Loam	18,624
55.	Keansburg Loam	18,048
56.	Elkton Silt Loam	18,024
57.	Montalto Gravelly Loam	17,216
58.	Weathersfield Gravelly Loam	17,024*
59.	Norfolk Sandy Loam (Imperfectly Drained Phase)	16,512
60.	Cordorus Loam	15,744
61.	Elkton Loam	15,616
62.	Sassafras Coarse Sandy Loam	15,424
63.	Chester Loam	15,104
64.	Lakewood Fine Sand	14,400
65.	Sassafras Sand (Flat Phase)	13,376
66.	Gloucester Stony Sandy Loam	13,184
67.	Lakawanna Loam	12,928
68.	Dunellen Sandy Loam	11,712*
69.	Dunellen Loam	11,072*
70.	Norfolk Fine Sand	11,520
71.	Chenango Fine Sandy Loam	11,136
72.	Alloway Silty Clay Loam	10,580
73.	Genesee Loam	10,176
74.	Dutchess Loam	9,728
75.	Woodstown Loam	9,280*
76.	Scranton Sandy Loam	8,832
77.	Sassafras Loamy Coarse Sand	8,640
78.	Colts Neck Sandy Loam	8,000
79.	Gloucester Loam	8,128
80.	Lehigh Shale Loam	7,872
81.	Norfolk Sand (Poorly Drained Phase)	7,744
82.	Dover Gravelly Loam	7,552
83.	Merrimac Gravelly Loam	7,424*
84.	Washington Loam (Gravelly Phase)	7,232
85.	Clyde Loam	6,848
86.	Colts Neck Loamy Sand	6,528
87.	Chenango Loamy Sand	6,464
88.	Reclaimed Tidal Marsh	6,400
89.	Berks Shale Loam	6,336
90.	Sassafras Loamy Sand (Flat Phase)	6,272
91.	Merrimac Sandy Loam	6,208*
92.	Hoosic Loam	6,080
93.	Shrewsbury Silt Loam	6,016

		Acres
94.	Shrewsbury Loam	6,016
95.	Hoosic Sandy Loam	5,888
96.	Portsmouth Loam	5,760
97.	Keansburg Fine Sandy Loam	5,696
98.	Croton Silt Loam (Poorly Drained Phase)	5,632
99.	Leon Sand	5,504
100.	Podunk Loam	5,376*
101.	Clyde Stony Loam	5,376
102.	Keyport Sandy Loam	5,376
103.	Keansburg Sandy Loam	5,184
104.	Birdsboro Silt Loam	5,020
105.	Colts Neck Loam	4,800
106.	Lakewood Gravelly Sandy Loam	4,544
107.	Merrimac Gravelly Sandy Loam	4,480*
108.	Fox Gravelly Loam	4,416
109.	Merrimac Fine Sandy Loam	4,352
110.	Made Land, Clay Pits, etc.	4,200
111.	Sassafras Sandy Loam (Flat Phase)	3,968
112.	Clyde Silt Loam	3,968
113.	Wallpack Silt Loam (Heavy Subsoil Phase)	3,648
114.	Muck (Intermediate Phase)	3,648
115.	Merrimac Loam	3,584*
116.	Wallpack Silt Loam	3,584
117.	Sassafras Sandy Loam (Imperfectly Drained Phase)	3,584
118.	Leom Fine Sand	3,456
119.	Culvers Loam	3,328
120.	Sassafras Silt Loam	3,264
121.	Dover Loam (Light Phase)	3,200
122.	Sassafras Loam (Shallow Phase)	2,944
123.	Keansburg Sand	2,816
124.	Dutchess Stony Loam	2,816
125.	Chenango Fine Sand	2,688
126.	Keyport Loam	2,688
127.	Watchung Silty Clay Loam	2,624
128.	Shrewsbury Fine Sandy Loam	2,624
129.	Fox Sandy Loam	2,496
130.	Collington Gravelly Loam	2,304
131.	Lansdale Stony Loam	2,304
132.	Wallpack Shale Loam	2,176
133.	Lansdale Shale Loam	2,112
134.	Keyport Clay Loam	2,112
135.	Sassafras Gravelly Sandy Loam (Flat Phase)	1,856
136.	Gloucester Sandy Loam	1,856
137.	Woodstown Sandy Loam	1,856
138.	Lehigh Silt Loam	1,792
139.	Muck (Shallow Phase)	1,792
140.	Dutchess Silt Loam	1,728
141.	Colts Neck Sandy Loam (Eroded Phase)	1,728
142.	Wallpack Stony Loam	1,664
143.	St. Johns Fine Sand	1,664
144.	Collington Fine Sandy Loam (Deep Phase)	1,472*
145.	Dutchess Shale Loam (Steep Phase)	1,472
146.	Wallpack Fine Sandy Loam	1,408
147.	Dover Loam (Sandy Phase)	1,344
148.	Roanoke Silty Clay Loam	1,344
149.	Keyport Fine Sandy Loam	1,280
150.	Weathers Field Gravelly Fine Sandy Loam	1,280
151.	Papakating Silty Clay Loam	1,280
152.	Colts Neck Gravelly Sand	1,152

		Acres
153.	Fox Loam	1,152
154.	Sassafras Fine Sand (Rolling Phase)	896
155.	Colts Neck Sandy Loam (Light Textured Phase)	832
156.	Elkton Clay Loam	832
157.	Chenango Loam	832
158.	Chenango Sandy Loam	768
159.	Collington Clay	704
160.	Collington Clay Loam	704
161.	Collington Loamy Sand	704*
162.	Wallkill Silty Clay Loam	704
163.	Watchung Silt Loam	704
164.	Chenango Silt Loam	576
165.	Elkton Sandy Loam	576
166.	Dover Fine Sandy Loam	512
167.	Wehadkee Silt Loam	512
168.	Roanoke Silt Loam	448
169.	Keansburg Silt Loam	384*
170.	Chenango Sand	384
171.	Birdsboro Fine Sandy Loam	320
172.	Colts Neck Fine Sandy Loam	256
173.	River Wash	256
174.	Gloucester Loam (Silty Phase)	128

Soil Types	164
Soil Series	51
Messec Types	10

APPENDIX 2

Acreage of Soil Types of New Jersey—Series Classification

State Soil Areas by Series

		Acres
*(1)	Sassafras Sand	480,320
(3)	Sassafras Gr. Sandy Loam	207,178
(5)	Sassafras Loam	181,152
(7)	Sassafras Sandy Loam	168,918
(11)	Sassafras Loamy Sand	100,864
(13)	Sassafras Fine Sandy Loam	90,536
(31)	Sassafras Coarse Sand	30,440
(36)	Sassafras Fine Sand	25,920
(37)	Sassafras Sand (Mixed Phase)	25,826
(43)	Sassafras Sandy Loam (D. P.)	23,488
(62)	Sassafras Coarse Sandy Loam	15,424
(65)	Sassafras Sand (Flat Phase)	13,376
(77)	Sassafras Loamy Coarse Sand	8,640
(90)	Sassafras Loamy Sand (F. P.)	6,272

		Acres
(25)	Lansdale Silt Loam	40,896
(48)	Lansdale Gr. Loam	23,040
(13)	Lansdale Stony Loam	2,304
(133)	Lansdale Shale Loam	2,112
	Total (4 types)	68,352
(29)	Montalto Stony Loam	31,040
(53)	Montalto Silt Loam	18,944
(57)	Montalto Gr. Loam	17,216
	Total (3 types)	67,200
(33)	Croton Silt Loam	27,008
(98)	Croton Silt Loam (Poorly, Dr. Ph.)	5,632
	Total (2 types)	32,640
(68)	Dunellen Sandy Loam	11,712
(69)	Dunellen Loam	11,072
	Total (2 types)	22,784

---

*The number preceding the soil name indicates the order of its extent in the state, as shown in Appendix 1.

		Acres
(111)	Sassafras Sandy Loam (F. P.)	3,968
(17)	Sassafras Sandy Loam	3,584
(120)	Sassafras Silt Loam	3,264
(122)	Sassafras Loam	2,944
(135)	Sassafras Gr. Sandy Loam	1,856
(154)	Sassafras Fine Sand	896
	Total (20 types)	1,394,896
(2)	Lakewood Sand	247,424
(27)	Lakewood Sand (Shallow Ph.)	31,808
(30)	Lakewood Sandy Loam (D. Ph.)	30,912
(64)	Lakewood Fine Sand	14,400
(106)	Lakewood Gr. Sandy Loam	4,544
	Total (5 types)	329,088
(70)	Norfolk Fine Sand	11,520
(19)	Collington Fine Sandy Loam	52,992
(22)	C. Sandy Loam	44,706
(26)	C. Loam	32,128
(41)	C. Sandy Loam (D.P.)	24,064
(46)	C. Sand	23,296
(130)	C. Gr. Loam	2,304
(144)	C. Fine S. Loam (D.P.)	1,472
(159)	C. Clay	704
(160)	C. Clay Loam	704
(161)	C. Loamy Sand	704
	Total (10 types)	183,074
(9)	Penn. Silt Loam	123,648
(14)	Penn. Shale Loam	79,232
(49)	Penn. Gr. Loam	22,464
	Total (3 types)	225,344
(58)	Weathersfield Gr. Loam	17,024
(150)	Weathersfield Gr. Fine Sandy Loam	1,280
	Total (2 types)	18,304
(16)	Dutchess Shale Loam	62,592
(34)	Dutchess Loam (Shaly Phase)	26,688
(74)	Dutchess Loam	9,728
(124)	Dutchess Stony Loam	2,816
(190)	Dutchess Silt Loam	1,728
(145)	Dutchess Shale Loam (Steep Phase)	1,472
	Total (6 types)	105,024

		Acres
(71)	Chenango Fine Sandy Loam	11,136
(87)	Chenango Loamy Sand	6,464
(125)	Chenango Fine Sand	2,688
(157)	Chenango Loam	832
(158)	Chenango Sandy Loam	768
(164)	Chenango Silt Loam	576
(170)	Chenango Sand	384
	Total (7 types)	22,848
(78)	Colts Neck Sandy Loam	8,000
(86)	Colts Neck Loamy Sand	6,528
(105)	Colts Neck Loam	4,800
(140)	Colts Neck Sandy Loam (Eroded Ph)	1,728
(152)	Colts Neck Gravelly Sand	1,152
(155)	Colts Neck Sandy Loam (Light, Tex. Phase)	832
(172)	Colts Neck Fine Sandy Loam	256
	Total (7 types)	23,296
(102)	Keyport Sandy Loam	5,376
(126)	Keyport Loam	2,688
(134)	Keyport Clay Loam	2,112
(149)	Keyport Vine Sandy Loam	1,280
	Total (4 types)	11,456
	Tidal Marsh	185,152
	Swamp	175,680
	Rough Stony Land	157,120
	Meadow	97,306
(28)	Muck	31,744
(114)	Muck (Intermediate)	3,648
(139)	Muck (Shallow)	1,792
	Total (3 types)	37,184
	Rock Outcrop	28,160
(40)	Coastal Beach	24,448
(110)	Main Land, Clay Pitts etc.	4,200
(173)	River Wash	256
	St. John's Sand	78,720
(143)	St. John's Sand	1,664
	Total 2 types)	80,384
(20)	Portsmouth Sandy Loam	52,672
(96)	Portsmouth Loam	5,760
	Total (2 types)	58,432

		Acres
(89)	Berks Shale Loam	6,336
(20)	Washington Loam	45,248
(84)	Wash. (Gr. Phase)	7,232
	Total (2 types)	52,480
(47)	Hagerstown Silt Loam	23,168
(39)	Dover Loam	25,664
(21)	Dover Loam (Light Phase)	3,200
(51)	Dover Stony Loam	21,632
(82)	Dover Gravelly Loam	7,522
(166)	Dover Fine Sandy Loam	512
(147)	Dover Loam (Sandy Phase)	1,344
	Total (7 types)	59,914
(10)	Chester Gravelly Loam	107,072
(17)	Chester Stony Loam	60,864
(63)	Chester Loam	15,104
	Total (3 types)	183,040
(18)	Gloucester Stony Loam	55,104
(45)	Gloucester Gr. Loam	23,296
(66)	Gloucester Stony Sandy Loam	13,184
(79)	Gloucester Loam	8,128
(136)	Gloucester Sandy Loam	1,856
(174)	Gloucester Loam (Silty Phase)	25,240
	Total (6 types)	101,696
(35)	Hoosic Gr. Loam	26,240
(92)	Hoosic Loam	6,080
(95)	Hoosic Sandy Loam	5,888
	Total (3 types)	38,208
(44)	Culvers Stony Loam	23,360
(119)	Culvers Loam	3,328
	Total (2 types)	26,688
(54)	Lakawanna Stony Loam	18,624
(67)	Lakawanna Loam	12,928
	Total (2 types)	31,552
(80)	Lehigh Shale Loam	7,872
(138)	Lehigh Silt Loam	1,792
	Total (2 types)	9,664

		Acres
(72)	Alloway Silty Clay Loam	10,580
(76)	Scranton Sandy Loam	8,832
(83)	Merrimac Gravelly Loam	7,424
(91)	Merrimac Sandy Loam	6,208
(107)	Merrimac Gr. Sandy Loam	4,480
(109)	Merrimac Fine Sandy Loam	4,352
(115)	Merrimac Loam	3,584
	Total (5 types)	26,048
(108)	Fox Gr. Loam	4,416
(129)	Fox Sandy Loam	2,496
(153)	Fox Loam	1,152
	Total (3 types)	8,064
(88)	Reclaimed Tidal Marsh	6,400
(104)	Birdsboro Silt Loam	5,020
(171)	Birdsboro Fine Sandy Loam	320
	Total (2 types)	5,340
(162)	Wallkill Silty Clay Loam	704
(42)	Shrewsbury Sandy Loam	23,616
(93)	Shrewsbury Silt Loam	6,016
(94)	Shrewsbury Loam	6,016
(128)	Shrewsbury Fine Sandy Loam	2,624
	Total (4 types)	38,272

		Acres
(113)	Wallpack Silt Loam (Heavy) (Subsoil Phase)	3,648
(116)	Wallpack Silt Loam	3,584
(132)	Wallpack Shale Loam	2,176
(142)	Wallpack Stony Loam	1,664
(146)	Wallpack Fine Stony, Sandy Loam	1,408
	Total (5 types)	12,480
(23)	Bermudian Silt Loam	43,556
(24)	Hyde Loamy Sand	41,216
(38)	Freneau Loam	25,856
(52)	Papakating Silt Loam	19,264
(151)	Papakating Silty Clay Loam	1,280
	Total (2 types)	20,544
(60)	Cordorus Loam	15,744
(73)	Genesee Loam	10,176
(85)	Clyde Loam	6,848
(101)	Clyde Stony Loam	5,376
(112)	Clyde Silt Loam	3,968
	Total (3 types)	16,192
(100)	Podunk Loam	5,376
(148)	Roanoke Silty Clay Loam	1,344
(168)	Roanoke Silty Loam	448
	Total (2 types)	1,792

		Acres
	Whippany Silty Clay Loam	22,144
(55)	Keansburg Loam	18,048
(97)	Keansburg Fine Sandy Loam	5,696
(103)	Keansburg Sandy Loam	5,184
(123)	Keansburg Sand	2,816
(169)	Keansburg Silt Loam	384
	Total (5 types)	32,128
(56)	Elkton Silt Loam	18,024
(61)	Elkton Loam	15,616
(156)	Elkton Clay Loam	832
(165)	Elkton Sandy Loam	576
	Total (4 types)	35,048
(59)	Norfolk Sandy Loam (Imperfectly Dr.)	16,512
(81)	Norfolk Sand (Poorly Dr. Phase)	7,744
	Total (2 types)	24,256
(75)	Woodstown Loam	9,280
(137)	Woodstown Sandy Loam	1,856
	Total (2 types)	11,136
(99)	Leon Sand	5,504
(118)	Leon Fine Sand	3,456
	Total (2 types)	8,960
(127)	Watchung Silty Clay Loam	2,624
(163)	Watchung Silty Loam	704
	Total (2 types)	3,328
(167)	Wehadkee Silt Loam	512

APPENDIX 3

Acreage of Soil Types of New Jersey—Textural Classification

Extent of Agricultural Soils of New Jersey—Textural Classification
Summary

	Well Drained				*Poorly Drained*		
	South Jersey	North Jersey	Entire State		Jersey	North Jersey	Entire State
	Acres	*Acres*	*Acres*	*Sands*	*Acres*	*Acres*	*Acres*
Gravelly ..	1,152	....	1,152		....	....	....
Coarse ...	30,440	....	30,440		....	....	....
Medium ..	542,848	384	543,232		94,784	....	94,784
Fine	38,336	2,688	41,024		5,120	....	5,120
Totals	612,776	3,072	615,848		99,904	....	99,904
				Loamy Sands			
Coarse ...	8,640	....	8,640		....	....	....
Medium ..	114,368	6,464	120,832		41,216	....	41,216
Totals ...	123,008	6,464	129,472		41,216	....	41,216
				Sandy Loams			
Stony	....	13,184	13,184		....	....	....
Gravelly ..	209,034	4,480	213,514		....	....	....
G. Fine ..	....	1,280	1,280		....	....	....
Coarse ...	15,424	....	15,424		....	....	....
Medium ..	281,080	28,928	310,008		112,832	....	112,832
Fine	148,008	17,728	165,736		8,320	....	8,320
Totals ...	653,546	65,600	719,146		121,152	....	121,152
				Loams			
Stony	....	217,408	217,408		....	5,376	5,376
Gravelly ..	2,304	255,744	258,048		....	....	....
Shale	....	161,792	161,792		....	....	....
Loam	226,850	181,440	408,290		83,576	38,144	121,720
Total	229,154	816,384	1,045,538		83,576	43,520	127,096
				Silt Loam			
	3,264	223,004	226,268		24,424	101,092	125,516
				Silty Clay Loams			
	....	....	....		10,580	28,096	38,676
				Clay Loams			
	2,816	....	2,816		832	....	832
				Clay			
	704	....	704		....	....	....

Detailed Extent of Soil Textures

SANDS (WELL DRAINED)

South Jersey	*Acres*	*North Jersey*	*Acres*
(1) Sassafras	480,320	(170) Chenango	384
(37) Sassafras (Mixed Phase)	25,856		
(46) Collington	23,296		
(65) Sassafras (Flat Phase)	13,376		
Total (4)	542,848	Total (1)	384

Total State (5)..... 543,232

SANDS (POORLY DRAINED)

South Jersey		*North Jersey*
(15) St. Johns Sand	78,720	None
(81) Norfolk (Poorly Drained)	7,744	
(99) Leon	5,504	
(123) Keansburg	2,816	
Total (4)	94,784	

Total State (4) ... 94,784

COARSE SANDS

South Jersey		*North Jersey*
(31) Sassafras	30,440	None
Total (1)	30,440	

Total State (1).... 30,440

GRAVELLY SAND

South Jersey		*North Jersey*
(152) Colts Neck	1,152	None
Total (1)	1,152	

Total State (1).... 1,152

FINE SANDS (WELL DRAINED)

South Jersey	*Acres*	*North Jersey*	*Acres*
(36) Sassafras	25,920	(125) Chenango	2,688
(70) Norfolk	11,520		
(154) Sassafras (Rolling) (Phase)	896		
Total	38,336	Total (1)	2,688

Total State (4).... 41,024

FINE SANDS (POORLY DRAINED)

South Jersey		*North Jersey*
(118) Leon	3,456	
(143) St. Johns	1,664	
Total (2)	5,120	None

Total State (2)...... 5,120

LOAMY SANDS (WELL DRAINED)

	South Jersey	*Acres*		*North Jersey*	*Acres*
(11)	Sassafras	100,864	(87)	Chenango	6,464
(86)	Colts Neck	6,528			
(90)	Sassafras (Flat Phase)	6,272			
(161)	Collington	704			
	Total (4)	114,368		Total (1)	6,464

Total State (5).... 120,832

LOAMY SANDS (POORLY DRAINED)

	South Jersey			*North Jersey*
(24)	Hyde	41,216		None
	Total (1)	41,216		

Total State (1)....... 41,216

LOAMY COARSE SANDS

	South Jersey			*North Jersey*
(77)	Sassafras	8,640		None
	Total (1)	8,640		

Total State (1)....... 8,640

SANDY LOAMS (WELL DRAINED)

	South Jersey			*North Jersey*	
(7)	Sassafras	168,918	(68)	Dunellen	11,712
(22)	Collington	44,706	(91)	Merrimac	6,208
(41)	Collington (Deep Phase)	24,064	(95)	Hoosic	5,888
(43)	Sassafras (Deep Phase)	23,488	(129)	Fox	2,496
(78)	Colts Neck	8,000	(136)	Gloucester	1,856
(103)	Keyport	5,376	(158)	Chenango	768
(111)	Sassafras (Flat Phase)	3,968			
(141)	Colts Neck (Eroned Phase)	1,728			
(155)	Colts Neck (lighttex).	832			
	Total (9)	281,080		Total (6)	28,928

Total State (15)....310,008

SANDY LOAMS (POORLY DRAINED)

	South Jersey			*North Jersey*
(20)	Portsmouth	52,672		None
(42)	Shrewsbury	23,616		
(59)	Norfolk (Imp.) (Dr. Ph.)	16,512		
(76)	Scranton	8,832		
(103)	Keansburg	5,184		
(117)	Sassafras (Imp.) (Dr. Phase)	3,584		
(137)	Woodstown	1,856		
(165)	Elkton	576		
	Total (8)	112,832		

Total State (8)..... 112,820

COARSE SANDY LOAMS

South Jersey	Acres	North Jersey	Acres
(62) Sassafras	15,424	None	
Total (1)	15,424		

Total State (1).... 15,424

GRAVELLY SANDY LOAMS

South Jersey	Acres	North Jersey	Acres
(3) Sassafras	207,178	(107) Merrimac	4,480
(135) Sassafras (Flat Phase)	1,856		
Total (2)	209,034	Total (1)	4,480

Total State (3).... 213,514

FINE SANDY LOAMS (WELL DRAINED)

South Jersey	Acres	North Jersey	Acres
(13) Sassafras	90,536	(71) Chenango	11,136
(19) Collington	54,464	(109) Merrimac	4,352
(144) Collington (Deep Phase)	1,472	(146) Wallpack	1,408
(149) Keyport	1,280	(166) Dover	512
(172) Colts Neck	256	(171) Birnsboro	320
Total (5)	148,008	Total (5)	17,728

Total State (10)... 165,736

FINE SANDY LOAMS (POORLY DRAINED)

South Jersey	Acres	North Jersey	Acres
(97) Keansburg	5,696	None	
(128) Shrewsbury	2,624		
Total (2)	8,320		

Total State (2).... 8,320

STONY SANDY LOAMS

South Jersey	Acres	North Jersey	Acres
None		(66) Gloucester	13,184
		Total (1)	13,184

Total State......... 13,184

GRAVELLY FINE SANDY LOAM

South Jersey	Acres	North Jersey	Acres
None		(150) Weathersfield	1,280
		Total (1)	1,280

Total State (1).... 1,280

SHALE LOAMS

South Jersey	Acres	North Jersey	Acres
None		(14) Penn	79,232
		(16) Dutchess	62,592
		(80) Lehigh	7,872
		(89) Berks	6,336
		(132) Wallpack	2,176
		(133) Lansdale	2,112
		(145) Dutchess (Steep) Ph.	1,472
		Total (7)	161,792

Total State (7).... 161,792

LOAMS (WELL DRAINED)

South Jersey

		Acres
(5)	Sassafras	184,290
(26)	Collington	32,128
(105)	Colts Neck	4,800
(122)	Sassafras (Shallow) (Phase)	2,944
(126)	Keyport	2,688
	Total (5)	226,850

North Jersey

		Acres
(21)	Washington	45,248
(34)	Dutchess (Shaly Ph.)	26,688
(39)	Dover	25,664
(63)	Chester	15,104
(67)	Lakawanna	12,928
(69)	Dunellen	11,072
(74)	Dutchess	9,728
(79)	Gloucester	8,128
(84)	Wash (Grav.) (Phase)	7,232
(92)	Hoosic	6,080
(115)	Merrimac	3,884
(119)	Culvers	3,328
(121)	Dover (Light) (Phase)	3,200
(147)	(Sandy Phase)	1,344
(153)	Fox	1,152
(157)	Chenango	832
(174)	Gloucester (silty) (Phase)	128
	Total (17)	181,440

Total State (22)..... 408,290

LOAMS (POORLY DRAINED)

South Jersey

(38)	Freneau	28,856
(55)	Keansburg	18,048
(61)	Elkton	15,616
(75)	Woodstown	9,280
(94)	Shrewsbury	6,016
(96)	Portsmouth	5,760
	Total (6)	83,576

North Jersey

(60)	Cordorus	15,744
(73)	Genesee	10,176
(85)	Clyde	6,848
(100)	Podunk	5,376
	Total (4)	38,144

Total State (10)... 121,720

GRAVELLY LOAMS

South Jersey

(130)	Collington	2,304
	Total (1)	2,304

North Jersey

(10)	Chester	107,072
(35)	Hoosic	26,240
(45)	Gloucester	23,296
(48)	Lansdale	23,040
(49)	Penn	22,464
(57)	Montalto	17,216
(58)	Weathersfield	17,024
(82)	Dover	7,552
(83)	Merrimac	7,424
(108)	Fox	4,416
	Total (10)	255,744

Total State (11) 258,048

STONY LOAMS (WELL DRAINED)

South Jersey	*Acres*	*North Jersey*	*Acres*
None		(17) Chester	60,864
		(18) Gloucester	55,104
		(29) Montalto	31,040
		(44) Culvers	23,360
		(51) Dover	21,632
		(54) Lakawanna	18,624
		(124) Dutchess	2,816
		(131) Lansdale	2,304
		(142) Wallpack	1,664
		Total (9)	217,408

Total State (9) 217,408

STONY LOAMS (POORLY DRAINED)

South Jersey		*North Jersey*	
None		(101) Clyde	5,376
		Total (1)	5,376

Total State (1) 5,376

SILT LOAMS (WELL DRAINED)

South Jersey		*North Jersey*	
(120) Sassafras	3,264	(9) Penn	123,648
		(25) Lansdale	40,896
Total (1)	3,264	(47) Hagerstown	23,168
		(53) Montalto	18,944
		(104) Birdsboro	5,020
		(113) Wallpack (Heavy Subsoil)	3,648
		(116) Wallpack	3,584
		(138) Lehigh	1,792
		(140) Dutchess	1,728
		(164) Chenango	576
		Total (10)	223,004

Total State (11) 226,268

SILT LOAMS (POORLY DRAINED)

South Jersey		*North Jersey*	
(56) Elkton	18,024	(23) Bermudian	43,556
(93) Shrewsbury	6,016	(33) Croton	27,008
(169) Keansburg	384	(52) Papakating	19,264
Total (3)	24,424	(98) Croton (Poorly Drained)	5,632
		(112) Clyde	3,968
		(163) Watchung	704
		(167) Wehadkee	512
		(168) Roanoke	448
		Total (8)	101,092

Total State (11) 125,516

SILTY CLAY LOAMS (POORLY DRAINED)

South Jersey	*Acres*	*North Jersey*	*Acres*
(72) Alloway	10,580	(50) Whippany	22,144
		(127) Watchung	2,624
Total (1)	10,580	(148) Roanoke	1,344
		(151) Papakating	1,280
		(162) Wallkill	704
		Total (5)	28,096

Total State (6) 38,676

CLAY LOAMS

South Jersey		*North Jersey*
(134) Keyport	2,112	None
(156) Elkton	832*	
(160) Collington	704	
	3,648	

*Poorly Drained.

Total State (3) ... 3,648*

CLAY

South Jersey		*North Jersey*
(159) Collington	704	None
Total (1)	704	

Total State (1) 704

APPENDIX 4

Soil Classification and Utilization in New Jersey

After several years of intensive field study, the soil survey of the state has been completed. In the conduct of field operations the soils of the state have been examined in minute detail, classified, and mapped. The resulting soil map shows in detail the location and extent of all soil types occurring within the state and represents: first, an economic classification of the producing power of New Jersey soil types and, second, an accurate inventory of our soil resources.

Method of Classification

The method of classifying the soils of the state is, therefore, based upon the following soil characteristics:

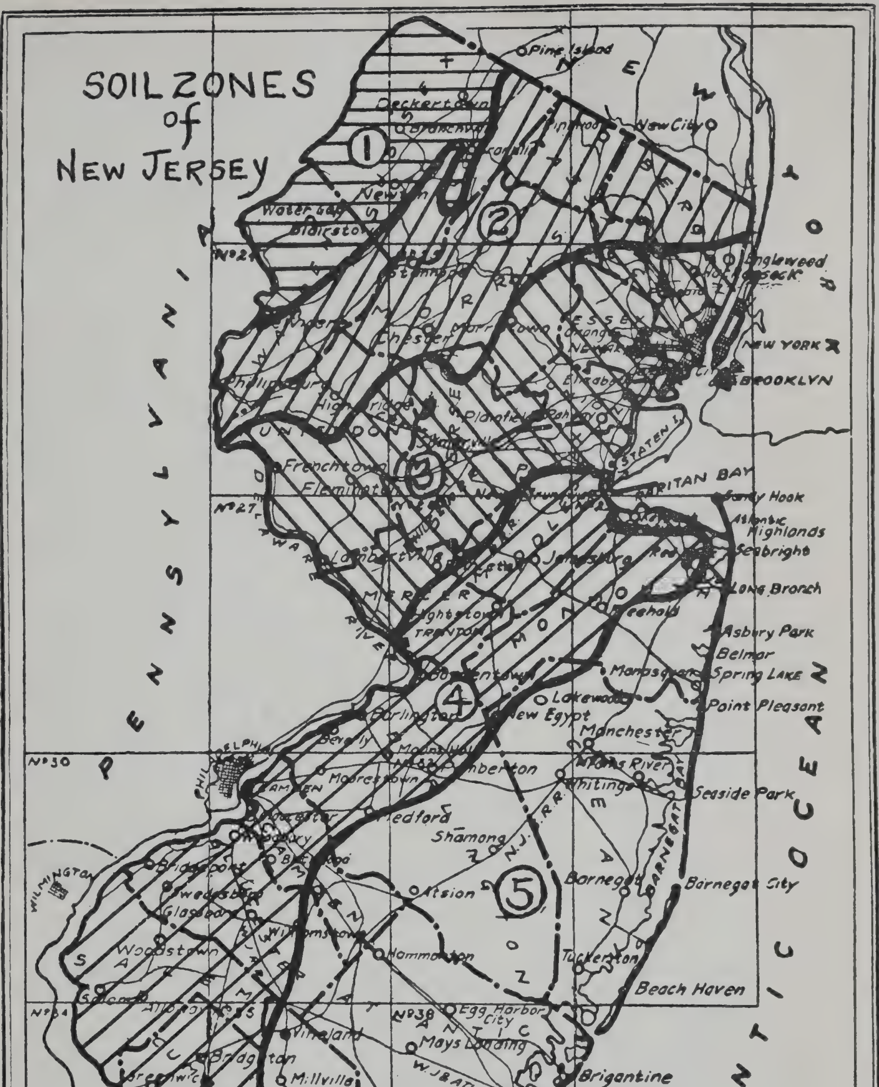
1. Geological Origin
2. Mode of Formation
3. Color
4. Topographic Positions
5. Drainage
6. Profile
7. Chemical Composition

The major unit of classification is the *Soil Series* into which all soils having the above identical characteristics are grouped. Soil series are further subdivided into *Soil Types,* a mechanical classification based upon the relative proportions of gravel, sand, silt, or clay which collectively make up the given soil mass. There may, therefore, be several soil types in every series. This is the official system of the Bureau of Soils of the United States Department of Agriculture and in current usage in the classification of all the soils of the United States.

The Soil Zones of New Jersey

Largely because of geological origin and topographic position there are five soil zones occurring within the state. These are shown in the accompanying map and may be described as follows:

Zone I.—Extending from the New York State line near Quarryville in a southwesterly direction to the Delaware just north of Belvidere. This is a



(*Facing page* 556)

rolling to hilly country, occasionally mountainous. The soils of the region are predominantly heavy and are derived from glaciated shales, limestones and sandstones. It is called the Kittatinny Mountain and Valley Belt.

Zone II.—Extending from the New York State line from a point just northeast of Quarryville to the Hudson, thence southwestward from Cresskill to the Delaware at a point about midway between Phillipsburg and Frenchtown. This is also a rolling, hilly, and occasionally mountainous region. The soils are predominantly heavy, well drained, and commonly loams derived from granite and gneiss on the uplands, whereas limestone soils occupy the valleys. This zone is the Highland Gneiss and Limestone Valley Belt.

The Trap and Red Sandstone and Shale Belt

Zone III.—Lies to the southeast of Zone II and extends from the Hudson at Cresskill and Raritan Bay at Perth Amboy southwesterly to the Delaware between Trenton and a point midway between Frenchtown and Phillipsburg. This is a gently rolling region with some relatively low stony ridges. The soils are predominantly derived from red sandstone and shales with some grayish shales and sandstones. The soils of the stony ridges owe their origin to the disintegration of dense trap rock.

Zone IV.—Extending on the northeast from Raritan Bay in an irregular southwesterly direction to the Delaware at Trenton and Port Norris on Delaware Bay. This is a level to gently rolling region having soils predominantly loams and sandy loams sometimes containing green sand marl. It is called the Heavy Coastal Plain Belt.

Zone V.—Lies southeast of Zone IV and extends along the coast from Raritan to Delaware Bay inland to the southeasterly boundary of Zone IV. This is a flat, level to very gently rolling region in which the soils are light, sandy and in places non-agricultural in character. Zone V is known as the Light or Sandy Coastal Plain Belt.

In each soil zone there are many thousands of acres of various soil types under cultivation and certain soil types are dominant. Collectively they represent the principal soil types of the state under cultivation. The description, extent, and present utilization of the outstanding soil types of each zone are as follows:

The Soils of Zone 1—*The Kittatinny Mountain and Valley Belt*

THE DUTCHESS SOILS

The Dutchess soils are the most important soils occurring in this zone. They are found in the Kittatinny Valley and represent what is locally known as slate and shale soils. They are easily recognized by their brownish color and the presence of varying quantities of grayish slate and shale fragments. Two types, classified as the Dutchess shale loam and the Dutchess loam, occur in this zone.

The Dutchess shale loam occupies 62,592 acres in the Kitatinny valley region. It occurs in gently rolling to steeply rolling positions as relatively low ridges traversing the valley. It is extensively developed south of Sussex and near Newton and Hainesburg. It is easily recognized by the light brownish color of the surface soil which contains considerable grayish or light brownish shale and slate material.

This soil is inclined to be droughty during the growing season. This is due to the rapid run-off of surface waters from the rolling surface and the high content of shale and slate found in the subsoil; under such conditions sufficient moisture to carry crops through seasons of protracted drought is not retained.

The chief crops grown on the Dutchess shale loam are rye, corn, and hay. Rye yields from 8 to 15 bushels per acre. With liberal applications of manure and careful treatment to conserve moisture, corn gives yields averaging about

30 bushels. The hot, dry weather of July and August frequently kills all grass, with the result that seedings last but from 1 to 3 years. Wheat or potatoes are not successful crops and should not be grown on this type.

The Dutchess loam is less intensive (36,416 acres), but much more productive than the shale loam. It contains only small amounts of shale and slate and is a much deeper soil. Wheat, rye, corn, and grass are also successfully grown on this type. Yields of wheat average about twenty bushels. In strong contrast to the shale loam, grass, especially timothy, is successfully grown on this type, yields averaging 1¼ tons, and under favorable conditions 1½ to 2 tons are produced. Yields of corn average about 40 bushels. Rye averages about 20 bushels per acre but is not extensively grown.

THE DOVER (LIMESTONE) SOILS

The Dover soils occur exclusively in the valleys and are derived from limestone. The surface soil is yellowish brown, sometimes slightly reddish and always mellow in structure. They generally occupy gently rolling topographic positions but are in a few cases level or steep. Drainage is good.

The Dover soils are among the most productive of the northern half of the state. On the Dover loam, corn, wheat, and oats are the chief crops, corn averaging about 50 bushels an acre, although often yields as high as 75 bushels are obtained. Oats produce 20 to 40 bushels, wheat 15 to 28 bushels, averaging about 20. Hay does well, timothy yielding from 1 to 2 tons per acre. Clover and potatoes are successful crops.

Of the agricultural types of the Dover soils found in Zone 1 the loam type occupies 25,664 acres found exclusively in the Kittatinny and Vernon Valleys. Locally near Quaker Church, Monroe, and Hamburg, the Dover fine sandy loam is important. Yields of general farm crops are somewhat lower on this type than those obtained from the heavier loam and because of its open structure it is apt to be droughty during dry seasons.

HOOSIC SOILS

The Hoosic soils comprise what are locally known as "gravel lands." The subsoils are gravelly and porous, making these soils some of the earliest of Zone 1. For this reason they are better suited to the production of special crops such as vegetables and potatoes than to general farm crops. The Hoosic loam, gravelly loam, and sandy loam are found in Zone 1. All are well drained and topographically occur in level areas frequently adjacent to stream bottoms.

The surface soils of the Hoosic soils are light brown or brown and underlain by lighter colored, yellowish brown subsoils always sandy and gravelly below 20 inches. Frequently, as in the case of the Hoosic gravelly sandy loam, gravel is abundant on the surface. This type is the most extensive of the Hoosic soils occurring in Zone 1, there being 26,240 acres within this area. This type occurs throughout the region but is more generally found near the present streams or at the border of bottom lands.

The Hoosic gravelly loam is a droughty soil, the subsoil being extremely porous. On the steeper and more sandy situations the productivity is very low. The more level areas are used for general farm crops such as corn, hay and pasture. Yields are fair to good depending upon moisture conditions during the growing season. Potatoes also give fair to good yields depending upon the same conditions.

HOOSIC LOAM

This type of which there are 6,080 acres in Zone 1, is the most productive of the Hoosic soils. It retains moisture better than the other types; crops are, therefore, more able to survive droughty seasons. Grass yields ¾ to 1½ tons per acre. Corn does well and matures earlier than on the Dutchess or Dover soils. Potatoes are a successful crop.

HOOSIC SANDY LOAM

The principal occurrence of this type is on Germany flats in the central part of Sussex County. Because of the porous nature of the subsoils of this type, it is somewhat droughty. General farm crops are successfully grown with the exception of grass, which fails to make a satisfactory stand. Corn yields vary from 25 to 70 bushels, oats 20 to 35, and potatoes 75 to 150 bushels per acre. Hay yields ¾ to 1 ton per acre but satisfactory stands are rare.

The Soils of Zone II—The Highland Gneiss Belt

CHESTER GRAVELLY LOAM

The Chester soils are the most extensive of all agricultural soils found in Zone II. They are derived from and occupy the highlands of granite and gneissic rock traversing parts of Warren, Hunterdon, and Morris counties in a general northeasterly and southwesterly direction of nearly parallel ridges. They are readily recognized by the brownish color of the surface soils and the varying amounts of angular gravel fragments of gneiss, which they always contain. Two agricultural types of the Chester soils occur in Zone II. The gravelly loam is the most extensive, 107,072 acres being found in this region. The Chester loam occurs to the extent of 15,104 acres.

Both types are well drained soils. The gravelly loam occurs on somewhat steeper situations than the loam and contains considerably more gravel. It is a strong soil and is utilized extensively in the production of corn, oats, rye, wheat, hay, and buckwheat. Rye yields are better than wheat on this soil. Flint and Dent varieties of corn are grown for grain, whereas Dent varieties are to be preferred for silage. Corn yields 25 to 70 bushels—averaging 40, oats 30 to 60 or in some cases 70 bushels, wheat 15 to 25—averaging about 18, rye 15 to 30, and hay 1 to 1½ tons.

CHESTER LOAM

The yields of general farm crops obtained on the Chester loam vary only slightly if at all from those grown on the gravelly loam. Because of the absence of excessive gravel, however, the loam is handled somewhat easier and it also occurs on more level situations, where cultivation is less difficult. It differs from the gravelly loam in that it contains only small amounts of gravel.

THE WASHINGTON LOAM

The Washington loam is found extensively in the Musconetcong and Pahatcong valleys; along the Delaware between Belvidere and Phillipsburg; and in the valley of the south branch of the Raritan between Kenvil and Califon. It also occurs in the uplands near Hazen, Schooley's Mountain, Drakestown, south of Mine Hill, near Budd Lake, east of Dover, and north of Mendham. This type is derived from ancient glacial drift which gives rise to a mellow brown loam overlying a reddish yellow friable subsoil. There are 45,248 acres occurring within the state.

The Washington loam has excellent drainage, nearly level topography and is a strong soil for general farm crops. Corn yields 35 to 80 bushels per acre, averaging about 50 bushels; oats produce 35 to 45 or 50 bushels; wheat produces 18 to 25 bushels; and hay 1 to 2 tons, averaging about 1½ tons per acre.

THE HAGERSTOWN SILT LOAM

The Hagerstown silt loam is extensively found—23,168 acres in Zone II—in the southwestern part of the Musconetcong valley and the Middle, Pahatcong, and Lopatcong Valleys as well as near Peapack, Gladstone, Pottersville and southwest of Ralston. This is a heavy limestone soil and no doubt the strongest and most productive type for general farm crops in the northern half of the state. It can be recognized by the brown color and mellow structure of the surface soil, the entire absence of gravel fragments on the surface, and occasional outcroppings of the bedrock limestone. It has nearly level to gently rolling topography resulting in easy cultivation.

This type yields from 40 to 90 bushels of corn per acre, the average yield being about 55 bushels. Oats yield 30 to 60 bushels, wheat yields about 23 bushels on the average, although the range is from 18 to 35. Hay ranges between 1 and 2 tons, the average yield being about 1½ tons per acre.

THE GLOUCESTER GRAVELLY LOAM

This type occurs extensively on the Glaciated gneiss uplands north of the terminal moraine which crosses the state in an irregular line from Belvidere in Warren County, just south of Boonton, and thence passes southeastward to Perth Amboy. Large areas of this type are also found in the northern parts of Passaic and Bergen counties. The surface soil is light brown or yellowish brown loam underlain by a yellow or brownish yellow subsoil. The surface soil is usually gritty and contains an abundance of gravel, most of which is fragments of gneiss rock. The largest and most important areas of this type are found near Morristown, Chatham, Summit, Morris Plains, Boonton, between Green's Pond and Danville in Warren County, north of Hackettstown, north of Bridgeville, and in the northern parts of Passaic and Bergen counties. It has a total area of over 30,000 acres.

The cultivation of this type is somewhat hindered by the presence of gravel, but good yields are nevertheless obtained. Corn yields 35 to 60 bushels per acre. Little wheat is grown on this type. Hay yields only fair, ranging from ¾ to 1¼ tons per acre. This is a strong fruit soil.

The Soils of Zone III—The Red Sandstone and Shale Belt

PENN SILT LOAM

This soil type occurs very extensively in Hunterdon, Somerset, Middlesex, and the northern half of Mercer County. There are 123,648 acres of this soil within the state and in addition 79,232 acres of the shaley phase, and 22,464 of the Penn gravelly loam. This land, especially when containing shale fragments, is locally known as "red shell" land. It has an unmistakable Indian red color both on the surface and in the subsoil. Part of the fields at the Agricultural Experiment Station is located on this soil type.

The Penn silt loam and gravelly loam are strong soils as evidenced by the fact that a considerable proportion of them have been constantly cultivated for more than 125 to 150 years without showing signs of depletion. Corn averages about 35 bushels, but yields of 50 or 75 bushels are not uncommon. Wheat produces 15 to 25 bushels, averaging about 18 bushels. Oats produce 30 to 40 bushels, rye produces 15 to 20 bushels, and timothy and clover hay 1 to 1½ tons.

The shaley phase of the Penn silt loam, known as Penn shale loam, contains fragments of red shale throughout the soil section and in most cases bedrock is encountered between 2 and 3 feet. This gives rise to a rather thin soil somewhat droughty, especially during dry seasons. This type is almost universally found on rather steep slopes and especially on those approaching streams. The yields on this phase in very favorable seasons compare favorably with those obtained on the Penn silt loam, but on the average are considerably lower.

THE LANSDALE SILT LOAM

There are about 66,112 acres of this soil found in New Jersey, where its occurrence is limited to Zone III. Approximately 23,000 acres of this is gravelly and 2,176 acres contain considerable shale. The Lansdale soils occur chiefly in Mercer and Hunterdon counties, especially near Quakertown, Cherryville, and Pennington. These soils occur closely associated with those of the Penn series, but are easily differentiated from them by the brownish color of the surface soil and yellowish brown subsoil as contrasted with the deep Indian red color of the Penn soils.

The Lansdale silt loam is a strong mellow soil which readily yields to cultivation. It produces from 40 to 70 bushels of corn, the average yield being about 45 bushels. Wheat yields from 15 to 25 bushels averaging about 18. Rye gives somewhat lower yields than wheat. Hay produces about 1¼ tons. Potatoes are successfully grown with good yields.

The shaley and gravelly phases of the Lansdale silt loam are somewhat shallower soils and inclined to be droughty. For this reason yields obtained on these types are considerably lower than those of the typical Lansdale silt loam, except during most favorable seasons.

THE MONTALTO SOILS

The Montalto soils are those found on the first, second, and third Watchung Mountains, the Palisades along the Hudson, Round Mountain in Hunterdon County, and the Highlands near Rocky Hill and between Lambertville and Neshanic. There are 37,184 acres within the state, 17,216 acres of which are gravelly. The surface soils are light brown or brown with a slight but decided reddish cast and are underlain by yellowish red subsoils. The Montalto soils usually contain varying amounts of hard, dense, angular gravel, sometimes to the extent of 50 per cent of the soil mass.

The Montalto soils are well drained. They usually occupy sloping positions sometimes quite steep and, being frequently gravelly, are somewhat hard to cultivate. Yields, however, are good depending somewhat on the gravel content and thickness of the soil above bed rock. On the gravelly types, corn yields from 35 to 60 bushels, oats yield 30 to 50 bushels, wheat yields 15 to 30 bushels, and hay 1 to 2 tons. Yields are somewhat higher in places containing smaller amounts of gravel. The Montalto soils are well adapted to fruit.

The Soils of Zone IV—The Heavy Coastal Plain Belt

SASSAFRAS SOILS

Four types of the Sassafras soils are important in Zone IV: the Sassafras Loam (approximately 180,000 acres), the Sassafras Sandy Loam, (approximately 100,000 acres), the Sassafras gravelly Sandy Loam (80,000 acres), and the Sassafras and the Sassafras Fine Sandy Loam (approximately 85,000 acres). The surface soils of these types are light brown to brown in color, mellow in structure, and underlain by reddish yellow subsoils frequently gravelly and lighter in texture below 24 inches. The porous subsoil assures good drainage. These heavy types of Sassafras soils occur generally distributed throughout Zone IV. They are the most extensive soils of the entire state adapted to general farm crops.

It is upon these soil types, which are especially adapted to the production of potatoes, that this crop is successfully grown in Monmouth County. The yield ranges from 200 to 300 bushels per acre on the loam. It is slightly less on the sandy loam. Corn is the next most important crop grown, yields averaging upward to 65 or 70 bushels per acre. Rye is grown chiefly as a cover crop following potatoes and is plowed under in the spring. In certain sections of central Jersey, rye is an important cover crop. Wheat is not extensively grown on these types, but high yields are obtainable. Clover and timothy are important crops yielding about 1½ tons. Next to corn, of the cereal crops oats is the most extensively grown, and yields are heavy.

COLLINGTON SOILS

Occurring closely associated with the Sassafras soils in Zone IV are the Collington Loam (approximately 30,000 acres), Sandy Loam (approximately 55,000 acres), and Fine Sandy Loam (approximately 50,000 acres). They also occur throughout the same general region except in Cumberland County and the southeastern parts of Salem and Gloucester counties. The Collington soils differ from the Sassafras only in containing varying amounts of green sand marl which imparts to the soil a greenish color and is easily detected in the soil as small, black specks that look like black pepper. The intensity of the greenish color varies according to the amount of green sand present.

In rare instances these soils contain green sand in such large quantities that they become heavy and sticky in texture and thus difficult to cultivate. By far the larger area, however, is very productive and produces yields about the same as the Sassafras Loam and Sandy Loam. This is true of potatoes as well as of the other general farm crops.

Zone V—The Light or Sandy Coastal Plain Belt

The soils of this region, which comprises over one-fourth of the land area of the state, are too sandy for the profitable production of general farm crops and potatoes except in local areas and on the southern half of the Cape May peninsula. In this region the Sassafras Sandy Loam, which sometimes contains gravel, is the chief soil type. Corn is the most extensive cereal crop grown and yields from 15 to 40 bushels; potatoes produce from 100 to 225 bushels; whereas hay yields from ½ to 1½ tons per acre. Little wheat, rye, or oats are grown in this region.

Much of this land is now in forest, but considerable of it is well adapted to the production of all truck crops and early varieties of tree and small fruits. The Sassafras sand, consisting of upwards to 425,000 acres, is the principal soil of the region. The surface soil is light brown overlying a reddish yellow subsoil. This type is of very light texture, but with careful cultivation and fertilization is capable of producing excellent crops of truck, peaches, apples, and small fruits. There are also many thousands of acres of Sassafras Sandy Loam and Gravelly Sandy Loam, Sassafras Loamy Sand, Sassafras Coarse Sand, and Sassafras Fine Sand occurring in Zone V. They are all good trucking and fruit soils. Over 100,000 acres of swamp are found within the region. This type of land is at present utilized or available for the production of cranberries. The St. Johns Sand (78,720 acres) is also well adapted to this crop. The following soils are very extensive in this zone, but better suited for forestry than the production of farm crops: Lakewood Sand, upwards to 240,000 acres; Lakewood Sandy Loam (deep phase), 30,912 acres; Lakewood Fine Sand, 14,400.

The Soil Types of the State Collectively

Agricultural Lands

There are two classes of agricultural lands; first, well drained, and second, imperfectly drained. Of the first class the following soil types predominate:

North Jersey *Zones I, II, III*	*Acres*	South Jersey *Zones IV, V*	
(1) Penn Silt Loam	123,648	(1) Sassafras Sand	480,320
(2) Chester Gravelly Loam	107,072	(2) Sassafras Sandy Loam	207,178
(3) Penn Shale Loam	79,232	(3) Sassafras Loam	181,346
(4) Dutchess Shale Loam	62,592	(4) Sassafras Sandy Loam	168,918
(5) Washington Loam	45,248	(5) Sassafras Loamy Sand	100,864
(6) Lansdale Silt Loam	40,896	(6) Sassafras Fine Sandy Loam	90,536
(7) Dutchess Loam (Shaly Phase)	26,688	(7) Collington Fine Sandy Loam	52,992
(8) Hoosic Gravelly Loam	26,240	(8) Collington Sandy Loam	44,706
(9) Dover Loam	25,664	(9) Collington Loam	32,128
Gloucester Gr. Loam	23,296	(10) Sassafras Coarse Sand	30,440
	560,576		1,389,428
All others (50)	323,366	All others (32)	237,824
Total	883,942	Total	1,627,252

Total Entire State, 2,511,194 Acres

Crop Adaptation

It is well established that certain crops and crop varieties grown in the state are better adapted to certain soils types than others. In an intensive system of cultivation with which our state is becoming more and more interested it is of the greatest importance that this fact be emphasized in order to obtain the maximum crop yields from a given acreage. The following soil types of the state are therefore recommended as best adapted to certain specific crops.

Wheat and Oats

North Jersey	*South Jersey*
Washington Loam	Sassafras Loam
Hagerstown Silt Loam	Sassafras Fine Sandy Loam
Lansdale Silt Loam	Sassafras Sandy Loam
Penn Silt Loam	Collington Loam
Chester Gravelly Loam	Collington Fine Sandy Loam
Dutchess Loam	Collington Sandy Loam
Dover Loam	

Timothy and Clover

Same as wheat and oats.

Corn

Same as wheat and oats, also Shrewsbury Loam, Keansburg Sandy Loam.

Rye

Same as wheat and oats, also Dutchess Shale Loam. Gives fair results on more sandy soils than other small grains.

Alfalfa

North Jersey	*South Jersey*
Washington Loam	Sassafras Loam
Penn Silt Loam	Collington Silt Loam
Hagerstown Silt Loam	Collington Sandy Loam
Dutchess Loam	Gravelly Sandy Loam
Lansdale Silt Loam	
Dover Loam	

Potatoes

Sassafras Loam
Sassafras Fine Sandy Loam
Sassafras Sandy Loam
Collington Loam
Collington Fine Sandy Loam
Collington Sandy Loam

Sweet Potatoes

All Sassafras and Collington sands and loamy sands together with sandy loams of these soils for later crop.

Orchard Fruits

Apples	*Peaches*
Early—Sassafras and Collington Sands and Loamy Sands	Same
Late—Gloucester Gr. Loam Chester Gr. Loam, Sassafras and Collington Sandy Loams. Gravelly Sandy Loams, Loams and Fine Sandy Loams	Sassafras and Collington Loams, Fine Sandy Loams, Gravelly Sandy Loams, Sandy Loams

Small Fruits

Early—Sassafras and Collington Sands and Loamy Sands
Late—Sassafras and Collington Sandy Loams, Gravelly Sandy Loams, Sandy Loams, Fine Sandy Loams.

Vegetables

Early—Same as small fruits.
Late—Same as small fruits.

Exceptions—Celery and Lettuce—Muck, Portsmouth, Sandy Loam.

Strawberries—Early—Sassafras and Collington Sands, Loamy Sands.

Late—Sassafras and Collington Flat Phases, Sandy Loams, Portsmouth Sandy Loam, Scranton Sandy Loam, Norfolk Sandy Loam, and Sand (Imperfectly Drained Phases).

Cranberries

Swamp
St. Johns Sand
Leon Fine Sand

ANIMAL AND DAIRY HUSBANDRY

All loam, silt loam, gravelly loams, and sandy loams. The following soils are first stream bottoms and excellent permanent pastures.

Bermudian Silt Loam	Codorous Loam
Freneau Loam	Genesee Loam
Papakating Silt Loam	Podunk

POULTRY

Sassafras Sands	Collington Loamy Sands
Lakewood Sandy Loams	

Expansion of Crop Production

Expansion in anyone of the various agricultural industries or crops should be attempted only upon favorable soil types. A careful intensive study of crop adaptation to soil types would also no doubt show that certain readjustments in cultural practices are highly desirable whereby the production of certain crops is curtailed on unprofitable soils and increased on more desirable soil types. It is to be hoped that in this connection the various agricultural interests, in considering their various problems, will study carefully the soil resources of the state and their relation to the particular problem at hand. More detailed soil information can be found in the various detailed soil survey reports of the state and is available through unprinted data of the Soils Department of the Station.

Drainage

The state drainage problem consists of two phases; first, Local, and second, General. The first phase involves the drainage of individual fields and farms already under cultivation. Unless such lands are needed for permanent pasture they represent an unproductive liability upon which the owner is paying taxes and from which he receives no return. Such soils when properly drained are very productive and soon repay the cost involved. There is great need throughout the state for educational work and assistance by Extension forces or otherwise in local drainage and the reclamation of local farm lands. It is estimated that there are approximately 200,000 acres of such lands which can and should be profitably reclaimed.

The general drainage problem is not so simple but nevertheless should receive careful study. Our salt marshes and fresh water swamps are the main problem. There is no question as to the fertility of these lands when drained. Their producing power is certain and the factor of irrigation by ditching is also present.

Mosquitoes

The mosquito problem is also of major importance. If the southern part of the state, which has thousands of acres of tillable land available for development when needed, is ever to be settled and profitably cultivated by the desirable type of farmer the mosquitoes must be controlled. Drain this territory and eliminate the mosquitoes as the first step toward the development of this territory. Soils which must be drained for successful cultivation are:

		acres
(1)	Tide Marsh (Salt)	230,000*
(2)	Swamp (Fresh)	175,680
(3)	Meadow	97,306
(4)	St. Johns Sand	78,720
(5)	Portsmouth Sandy Loam	52,672
(6)	Bermudian Silt Loam	43,556
(7)	Hyde Loamy Sand	41,216
(8)	Muck	31,744
(9)	Croton Silt Loam	27,008
(10)	Freneau Loam	25,804
		803,706
	All others (42)	287,804
	State Total	1,091,510

---

*Estimated South Jersey only.

Non-Agricultural Soils

The non-agricultural soils of the state with their relative extents are as follows:

North Jersey

(North of Trenton and New Brunswick) Zone I, II, III

	Acres
(1) Rough Stony Land	157,120
(2) Chester Stony Loam	60,864
(3) Gloucester Stony Loam	55,104
(4) Montalto Stony Loam	31,040
(5) Culvers Stony Loam	23,360
All others (6)	60,224
Total	387,712

South Jersey

(South of Trenton and New Brunswick) Principally Zone V, Local Areas in Zone IV

	Acres
(1) Lakewood Sand	247,424
(2) Lakewood Sand Shallow Phase	31,808
(3) Lakewood Sandy Loam Deep Phase	30,912
(4) Lakewood Fine Sand	14,400
(5) Gravelly Sand Loam	4,544
Total	329,088

Total entire state 716,800 acres

These soils should for the present at least be utilized only as forest lands or permanent pasture.

Land Development Policy

In these times of automobiles, radio, good roads, free bridges and tunnels, real estate expansion, and increased population, more and more of our agricultural lands are being taken up by towns and cities with a corresponding decrease in improved lands available for cultivation. Between 1920 and 1925 many acres of farm lands were thus lost. In the next quarter century this loss will no doubt be much greater. It is impossible to forecast accurately what effect this movement will have on our present agricultural situation. All lands will certainly increase in value as will the consumption of farm products. This raises the problem of more intensive cultivation of farm crops, increased yield per acre, and the opportunity of expanding local markets. To these may be added the problem of keeping on the farm the man who has sold his place for real estate development as well as of attracting desirable farmers from sections outside the state. If either of these classes are to be "Sold" New Jersey farms, obviously we must have available attractive acreage. Where are these lands to be found? Should we clear and drain lands as yet undeveloped, or are other desirable lands available? Our agricultural interests must meet all these problems in a positive way. Establish a definite land development policy and be in a position to place prospective farmers only on lands best suited to their special requirements. A study of the soil resources of the state will point out where such lands are located.

Soil Types As a Basis for Station Experimental and Demonstration Projects

Heretofore, practically all the experimental and demonstration projects of the station have been planned and carried out without great regard to the particular soil conditions involved and results obtained interpreted as applicable to all soil types. Our knowledge of the soils of the state as well as that acquired from the advance of soil science during the past few years has increased rapidly and, as described, it has become evident that the soils of the state may be and have been classified according to their economic producing power.

Even the casual observer will note, in traveling about the state, the vast variety and differences of our soil types. The experience of other states, secured from experimental data, has shown very conclusively that in a general way certain practices and treatments give certain results on all soil types with the same crops; as for example, lime always increases clover yield regardless of the soil type involved. But the same experiments have also shown that the rate of increase in clover yields varies *widely with the soil type* and further that certain treatments and crops prove profitable on some soil types and are of no value on others and that other fertilizer treatments give different effects on the same crops on different soils. Fertilizer treatments on one soil type are therefore not necessarily applicable to other soil types.

Although we have no experimental evidence showing that this same principle is applicable to New Jersey soils there is every reason to believe that such is the case. It is further believed that the time has arrived when all experimental and demonstration work of the station be placed more upon a soil foundation and that soil type be considered as one of the major factors in selecting the location for all such work. Such a procedure enables us to collect reliable data on the response of various soil types to crops and soil treatment and by establishing new projects upon representative *soil types* having the greatest extent within the state, we can secure results that will benefit the greatest numbers farming upon their identical soil types. By having all experiments on typical soils, as our knowledge of the response of these soils to crops and fertilization increases, results obtained are applicable to these same soils throughout the whole state under the same climatic condition and the conclusions drawn are of the utmost scientific accuracy. On such a basis, results obtained in one county are therefore applicable in an adjoining county and in other counties within the same climatic zone, and by such correlation much duplication of field demonstration and experimental work can be avoided.

It is further suggested that insofar as possible, as much of the present field experimental and demonstration work of the station as is at present under way, be correlated with the soil types involved so that no time be lost in collecting all possible data on the response of our soil types to specific crop and fertilizer treatments.

To such other state or station departments as may need cooperation or assistance in problems involving soil conditions, trustworthy and accurate information concerning the soils of the state is now available through the soils department of the station.

APPENDIX 5

Burlington County Fertilizer Experiments—Sweet Corn

John Heal's Field

Burlington County, N. J.

Soil: Sassafras loamy sand.

Total area: About 28,000 square feet.

Plots: 59 plots, each 18 feet by 19 feet 2 inches—345 square feet or .00792 acres.

The rows are 3 feet 10 inches wide for corn, there being 5 rows in a plot, and the hills are about 18 inches apart in the row. There is an alley 18 inches wide crossing the rows, between the plots, which was unfertilized. The crop is chopped out of it.

Three check plots in the field.

Previous History

1924—Peas followed by tomatoes.

1925—Peppers 6¼-10-4.

Where corn was grown previously, 800 pounds of 5-8-5 was used.

History of Experiment—1926

In winter of 1925-26, a light application of horse manure was broadcast over the entire field and plowed about March 20 to 25 to a depth of 8 inches. One-half ton $Ca(OH)_2$ was applied about March 29 and dragged in.

Field fertilized and planted April 12, 1926. It had previously been marked out in rows 3 feet 10 inches apart, the marker making a furrow about 5 inches deep. This was the farmer's customary practice.

When fertilizing, about half of the field was fertilized in the row, below the seed. The fertilizer was spread evenly (base rate 500 per acre) in the marker furrows. Then a double disk attachment ahead of the planter threw dirt into furrows, filling them up and covering the fertilizer, and the planter which followed put the seed in this filled furrow about 2 to 3 inches deep, and covered it. This was the farmer's ordinary practice, except that he used a drill to spread this fertilizer instead of doing it by hand.

On the rest of the plots, the corn was planted first with the same implements and the fertilizer was spread in a band about 3 inches broad in the packer mark over the row, or in 2 narrow bands about 3 inches each side of this packer mark. In these two cases the fertilizer was not covered or mixed with the soil.

The crop was Burlington County white corn, a variety of field corn suited to table use. It matures very quickly.

Farmer's Future Plans for 1926

This crop (corn) is supposed to mature July 1 to 15. It will be followed by snap beans seeded July 20 to August 1. These will mature in about 6 weeks and the field will then be seeded to rye, which will be plowed under the next spring. No fertilizer will be used on the beans or rye.

Fertilizer

The fertilizer, except the grower's mixture, was mixed by hand, the problem being to test the effect of different nitrogen carriers, different methods of application, and different rates of application. All of the plots, except mixture 13 received fertilizer at the rate of 500 pounds per acre, except those in the tests on rates of application, and the analysis was 5-8-5, except with a few plots used to test a potash carrier.

MIXTURES

(1) 5-8-5-1/3 N from tankage, 2/3 from $NaNO_3$.
(3) 5-8-5-1/3 N from tankage, 2/3 from Leuna saltpeter.
(4) 5-8-5-1/3 N from tankage, 2/3 from cyanamid.
(5) 5-8-5-1/3 N from each: tankage, $NaNO_3$, $(NH_4)_2SO_4$.
(9) 5-8-5-2/3 N from tankage, 1/3 from $NaNO_3$.
(12) Growers' mixture 5-8-5.
(13) 10-16-10-1/5 N from tankage, 4/5 Leuna saltpeter (250 pounds per acre).

The plots used to test the rate of application were treated with Number 5 mixture.

POTASH FERTILIZER

In 1925, there had been some injury to corn in Burlington County, which was attributed to fertilizer. This fertilizer contained K_2O in the form of a double manure salt, so four mixtures were made by hand, using tankage, $NaNO_3$-$(NH_4)_2SO_4$, in equivalent amounts in each mixture, as the N carriers, 16 per cent acid phosphate, and the double manure salt (sulfate of potash-magnesia). These fertilizers were made with the following analyses: 5-8-3; 5-8-5; 5-8-7; and 5-8-10. In addition some of the commercial mixture (5-8-5) which was thought to have produced the injury was obtained. These were all applied at the rate of 500 pounds per acre in the row before seeding.

APPENDIX 6

Monmouth County Fertilizer Experiments— Sweet Corn and Tomatoes

Warnock's Field

Keyport, N. J., Monmouth County

Crop: Sweet corn and tomatoes.
Soil: Sassafras loamy sand.
Plots: 61 plots; each 24 feet by 27 feet—648 square feet or 0.0148 acre (36 hills); 2 plots (30 hills).

The field is flat, and the soil is uniform.

A Truog lime requirement test on this soil showed little or no lime requirement.

Previous History

Various truck crops for last three years. Fertilizer has been uniformly of the formula 4-8-7 applied in the row at the time of seeding at the rate of about 600 pounds per acre. Side dressings of nitrate of soda were used on some of the crops.

Manure—about 6 tons per acre annually. Last application before experiment in fall of 1925.

Lime—about 1923—2,200 pounds burned oyster shell per acre.

Cover crops of rye were grown each year, planted as soon as practicable after the truck crop was removed, and plowed under the following spring.

History of Experiment—1926

The field was plowed early to a depth of 7 or 8 inches. On April 23, 34 plots were fertilized, and they, with two checks, were planted to sweet corn, 4 seeds to a hill, all the work being done by hand.

The field had been check rowed 4 feet by 4½ feet and each plot (except two) contained 36 hills. The two exceptions had only 30 hills, as the outside row was missing. These are plots 31 and 42, fertilized to 1,200 pounds on side, no side dressing and 600 pounds concentrate in row, no side dressing respectively.

The fertilizer was of two mixtures, 4-8-7, with 1/3 of the NH_4 from each of the following: tankage, $NaNO_3$, $(NH_4)_2\ SO_4$; 16 per cent acid phosphate and KCl approximately 50 per cent in analysis for the other ingredients. The other mixture was a concentrate 8-16-14 using leuna saltpeter for 4/5 and tankage (10 per cent) for 1/5 of the NH_4; 45 per cent treble superphosphate and KCl for its ingredients.

The fertilizers were applied with two factors in view, 1. Rate of application and 2. Method of application. The 4-8-7 was applied at the rates of 300 pounds, 600 pounds, 900 pounds, 1,200 pounds, and 1,500 pounds per acre, while the concentrate was applied only at the rate of 600 pounds. The methods used were as follows: 1. broadcast, 2, in a mass in the hill before seeding, 3. in a disc about 12 to 15 inches in diameter on top of the hill after seeding, not harrowed in, and 4. in two small trenches in bands about 1 inch wide and 6 to 10 inches long on two sides of the hill after seeding, not harrowed in, or covered.

The seeds were planted about 1½ inches deep, so this last method put the fertilizer on a level with the seed and about 3 inches from it in a lateral direction.

The variety of corn planted was home-grown Giant Golden Bantam. Planted 1 to 1½ inches deep, 4 kernels to a hill.

The fertilizer in method 2 was mixed with the soil a little before the seeds were dropped.

Tomatoes

On April 27, 9 plots for tomatoes were fertilized, all of the fertilizer being applied in the hill and then mixed slightly with the soil. The fertilizer used was 4-8-7 applied at the rates of 300 pounds, 600 pounds, and 900 pounds per acre. As in the corn, each plot consists of 36 hills set 4 by 4½ feet.

On May 10, 16 plots of tomatoes were fertilized and all plots were planted to an early tomato. The variety was Sunny Brook Earliana, from home-grown seed, the strain being obtained from a seed house about 3 seasons previously.

The applications made May 10 were: 1. broadcast at the rates of 600 pounds, 900 pounds, 1,200 pounds, and 1,500 pounds, and 2. applied at the same rates in a ring around the plant. The fertilizer was kept 3 inches from the plant and put in a band about 6 inches broad. This fertilizer was all 4-8-7. All of the fertilizer on the tomatoes and 1/3 of the NH_4 from each of $NaNH_4$, tankage, and $(NH_4)_2SO_4$.

LIBRARY
UNIVERSITY OF ILLINOIS
URBANA

THE LIBRARY OF THE
AUG 1 1927
UNIVERSITY OF ILLINOIS

UNIVERSITY OF ILLINOIS-URBANA
3 0112 018065109